PIRCS: Approach and Lessons Learned

William Gutowski
Iowa State University

With thanks to
R.Arritt, G. Takle,
Z. Pan, J. Christensen,
R. Wilby,L. Hay, M. Clark,
PIRCS modelers

http://rcmlab.agron.iastate.edu

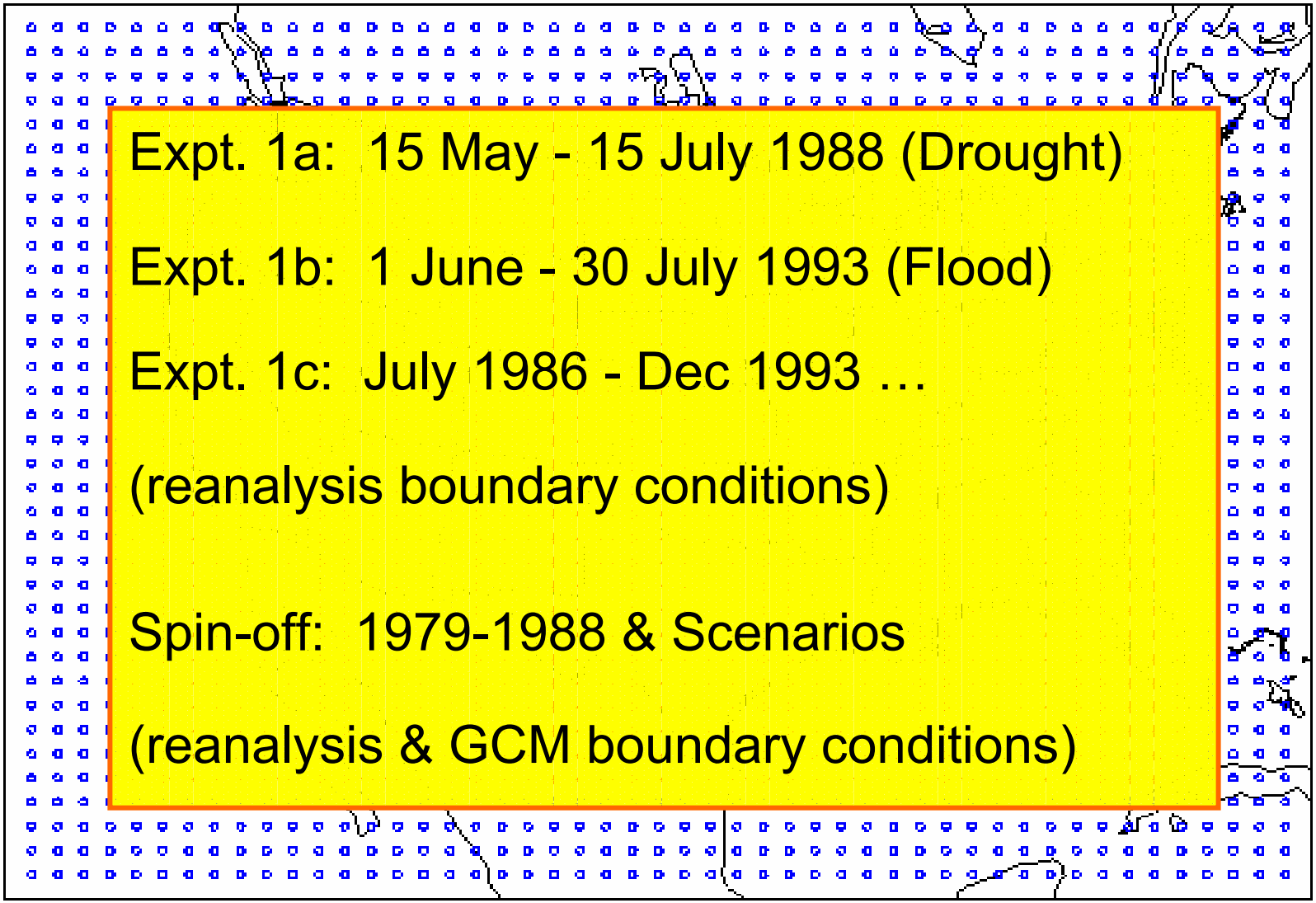
PIRCS: Approach and Lessons Learned

1. History - PIRCS 1a & 1b
2. PIRCS 1c
3. Spinoff: 10-yr “ensemble”
4. Transferability
5. Impacts
6. Summary

Project to Intercompare Regional Climate Simulations (PIRCS)

- Systematically examine regional climate model simulations to identify common successes and errors
  - "Regional" ≠ "limited area"
  - Different models, parameterizations, computer hardware
  - Same domain and period of simulation
  - Consistent analysis procedures and software
- Provide a starting point for other community efforts (e.g., NARCCAP)

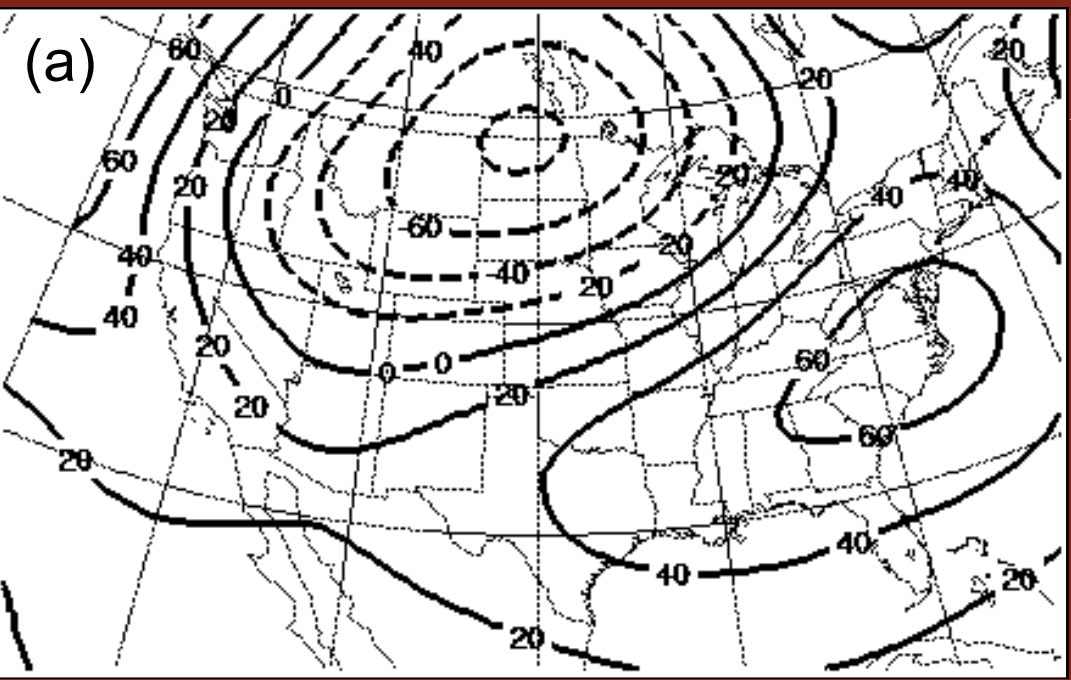
PIRCS Experiments



PIRCS Participants

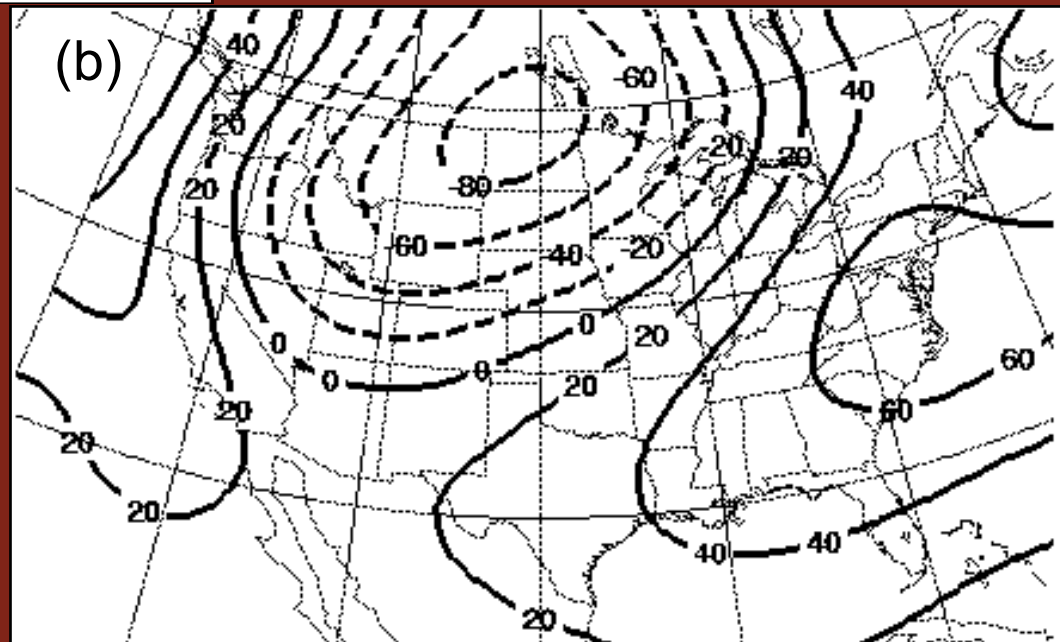
- Danish Met. Inst. (HIRHAM4; J.H. Christensen, O.B. Christensen)
- Université du Québec à Montréal (D. Caya, S. Biner)
- Scripps Institution of Oceanography (RSM; J. Roads, S. Chen)
- NCEP (RSM; S.-Y. Hong)
- NASA - Marshall (MM5/BATS; W. Lapenta)
- CSIRO (DARLAM; J. McGregor, J. Katzfey)
- Colorado State University (ClimRAMS; G. Liston)
- Iowa State University (RegCM2; Z. Pan)
- Iowa State University (MM5/LSM; D. Flory)
- Univ. of Maryland / NASA-GSFC (GEOS; M. Fox-Rabinovitz)
- SMHI / Rossby Centre (RCA; M. Rummukainen, C. Jones)
- NOAA (RUC2; G. Grell)
- ETH (D. Luethi)
- Universidad Complutense Madrid (PROMES; M.Gaertner)
- Université Catholique du Louvain (P. Marbaix)
- Argnonne / Lawrence Livermore National Labs (MM5 V3; J. Taylor, J. Larson)
- St. Louis University (Z. Pan)

Z(500 hPa) Differences. Period = PIRCS 1b - PIRCS 1a

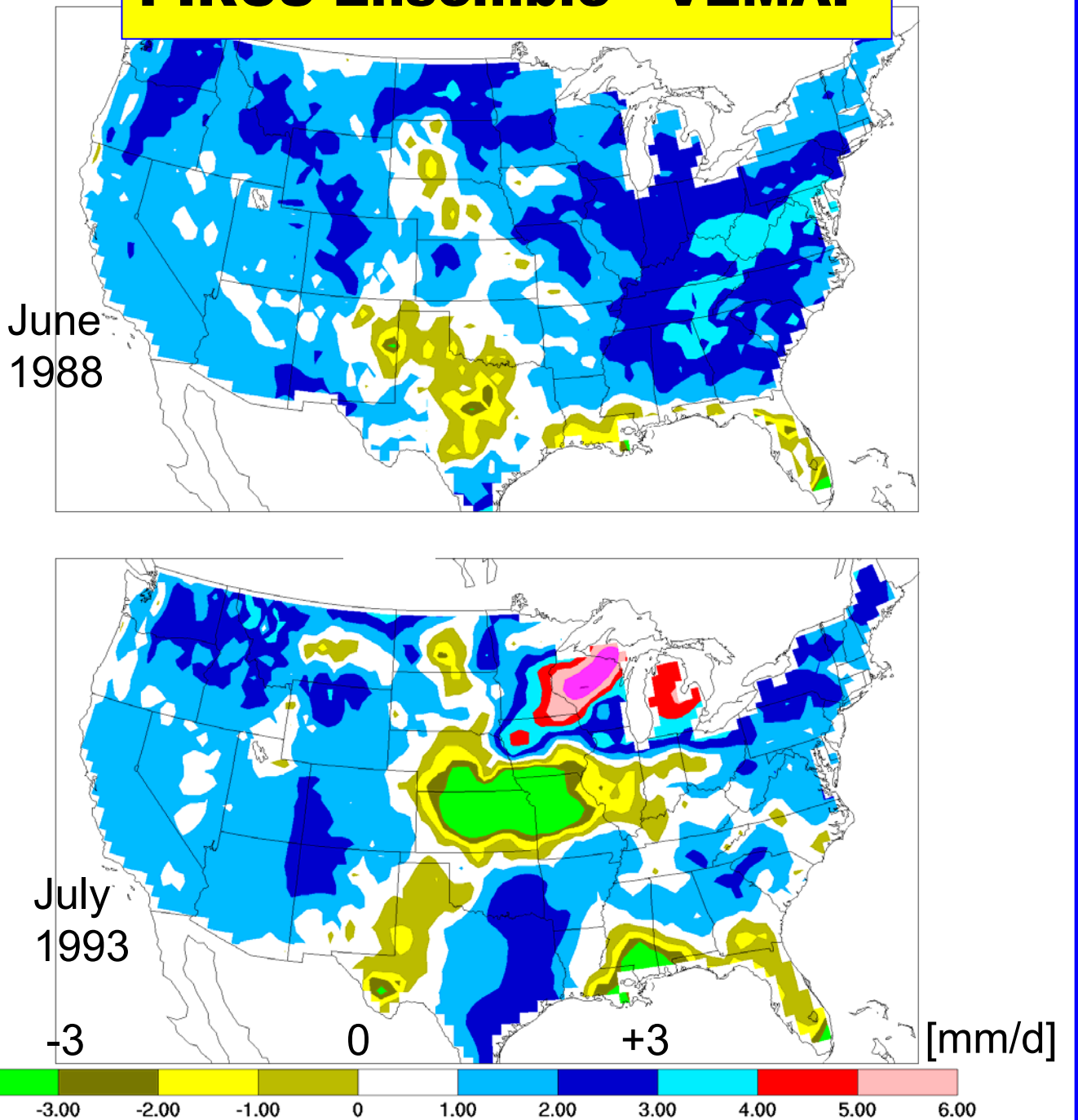


Reanalysis

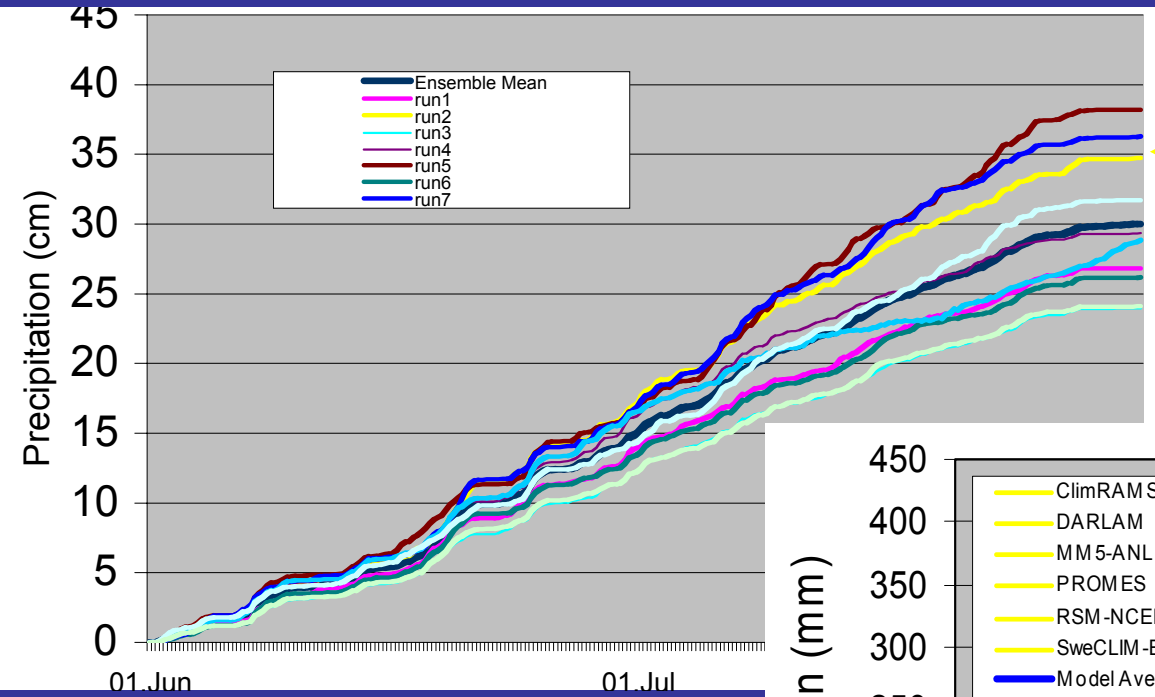
PIRCS Ensemble



PIRCS Ensemble - VEMAP

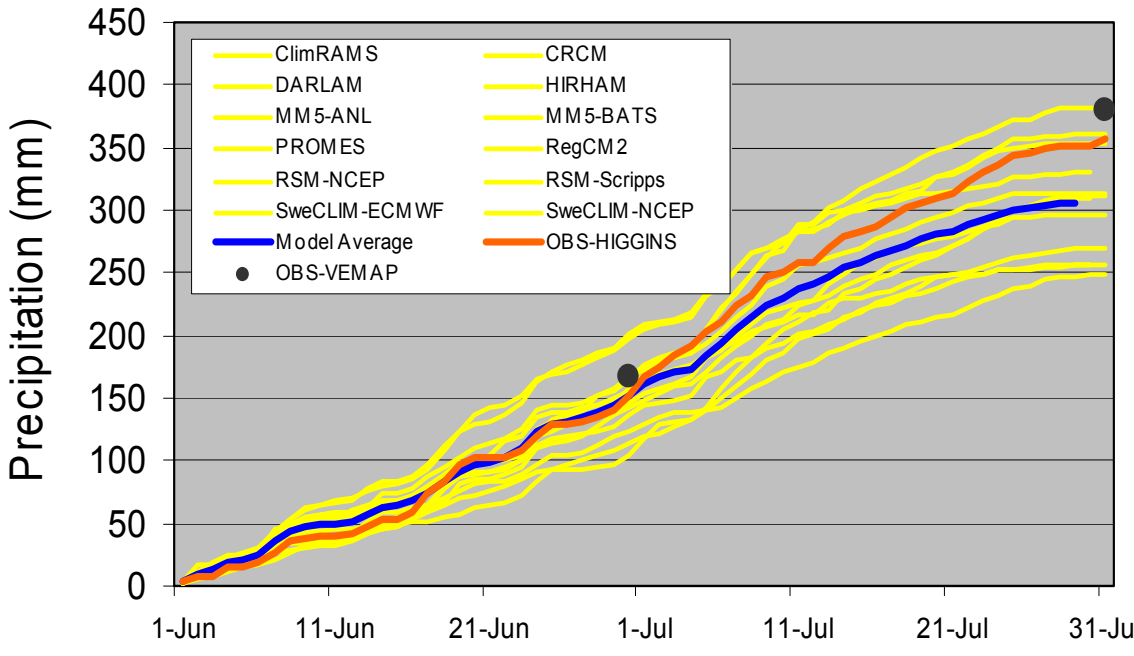


Area-averaged precipitation in the north-central U.S.



Mixed Physics

Multi-Model (PIRCS 1B)



PIRCS 1a & 1b: Conclusions

- **Ensembles are important**
  - –Reveal common & unique problems
  - –No model is “best”
- **Distinction between problems of**
  - –Lateral forcing/dyamics (“common”)
  - –Surface processes (“unique”)
- **Interannual climate variation**
  - –Simulated in large-scale dynamics
  - –Muted in precipitation response

PIRCS: Approach and Lessons Learned

1. History - PIRCS 1a & 1b
2. PIRCS 1c
3. Spinoff: 10-yr “ensemble”
4. Transferability
5. Impacts
6. Summary

PIRCS 1c: Participants

Model	Lead Investigator
MM5-ISU	Chris Anderson
MM5-ANL/LLNL	John Taylor
RSM-Scripps	John Roads
SweCLIM	Colin Jones
CRCM	Sebastian Biner

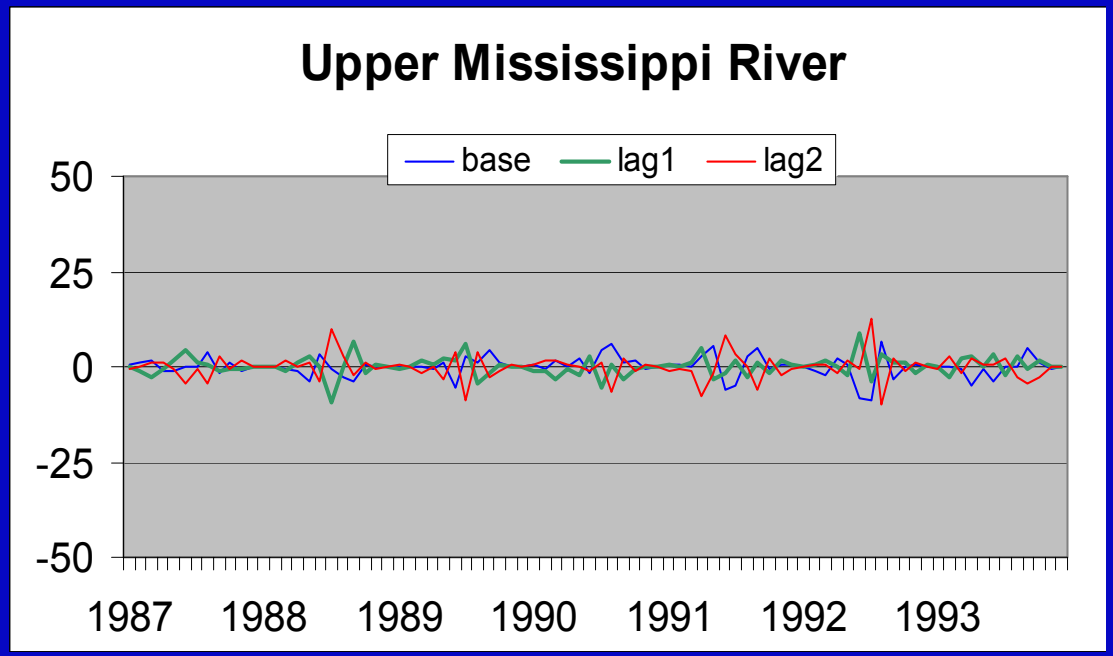
Ensemble spread: Upper Ms. River

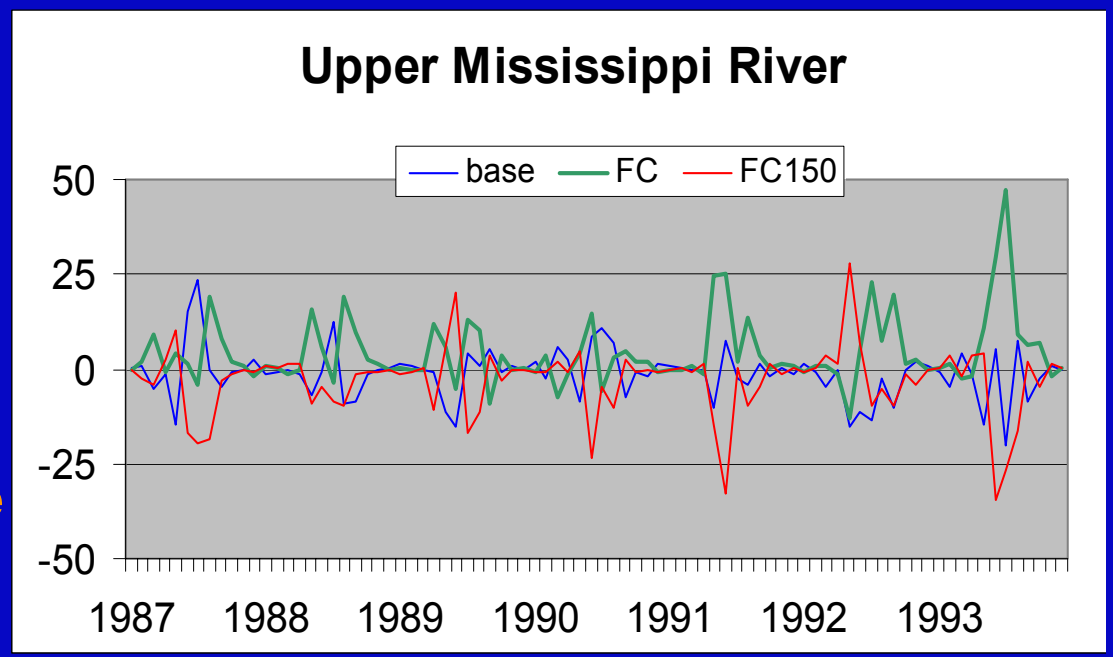
lagged ensemble

- Shown: % variations of precip. For each member about the mean for that ensemble
- Internal variability is less than variability due to physics
- Large year-to-year variations in spread due to physics
- The types of variability do not appear to be correlated

physics ensemble

(RW Arritt, 2004)





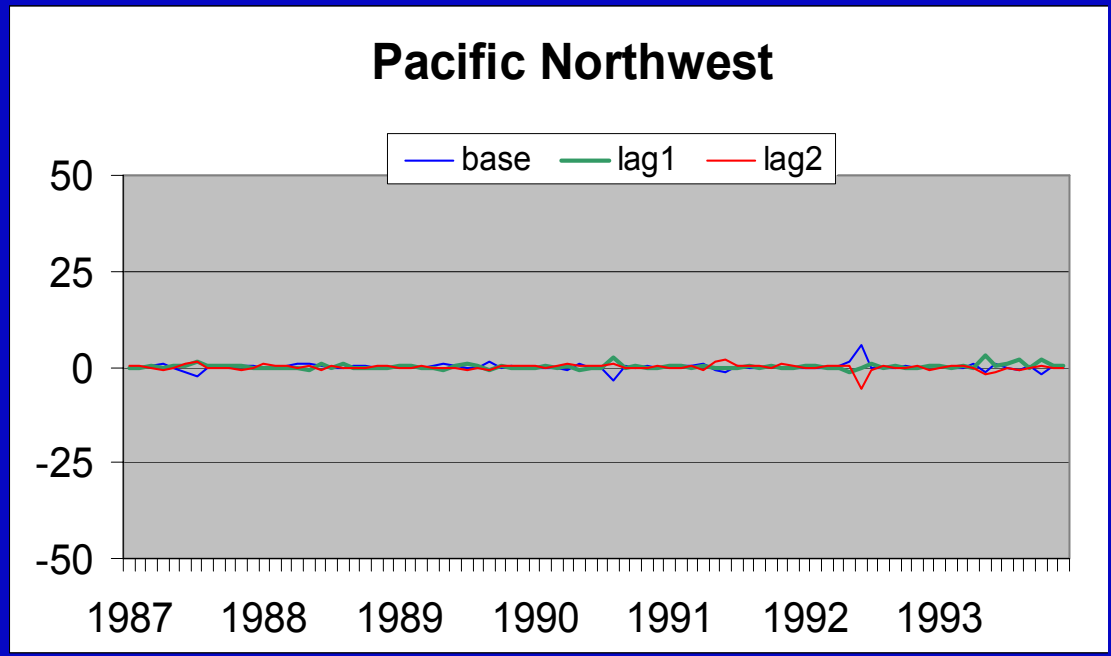
Ensemble spread: Pacific Northwest

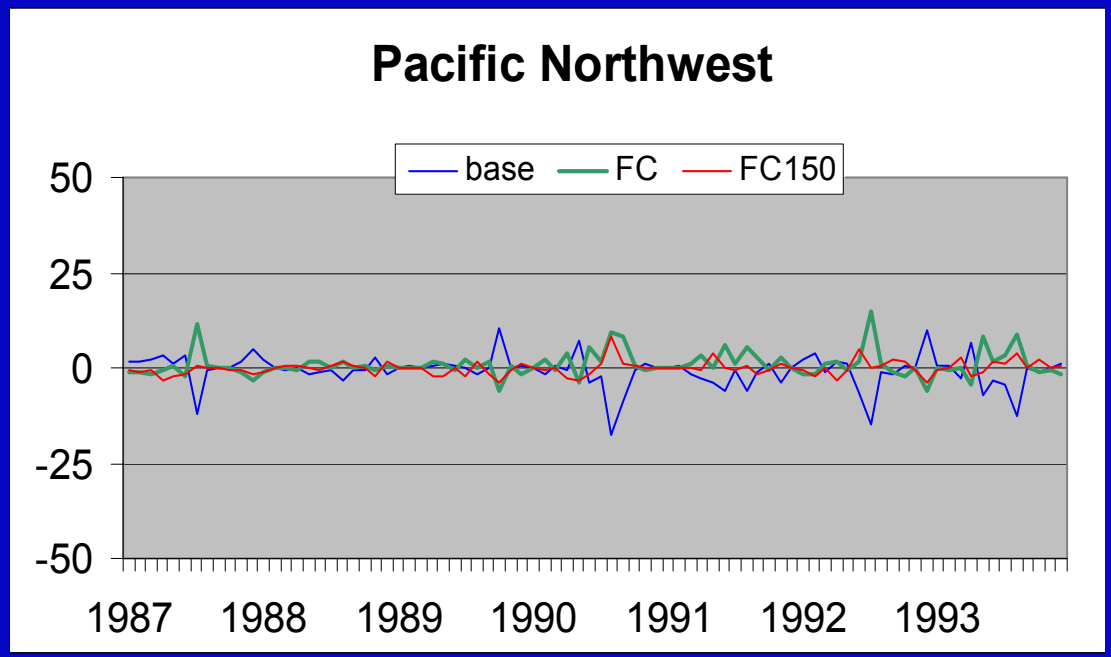
lagged ensemble

- Internal variability is extremely small because most precipitation occurs in the winter, when large-scale control is strong
- Physics variability also is smaller than for central U.S., even in summer

physics ensemble

(RW Arritt, 2004)





Current Status

- Runs and analysis for PIRCS 1C are presently at an early stage
- Potential coordination with other projects:
  - perform complementary simulations
  - suggest diagnostics

Details: http://rcmlab.agron.iastate.edu

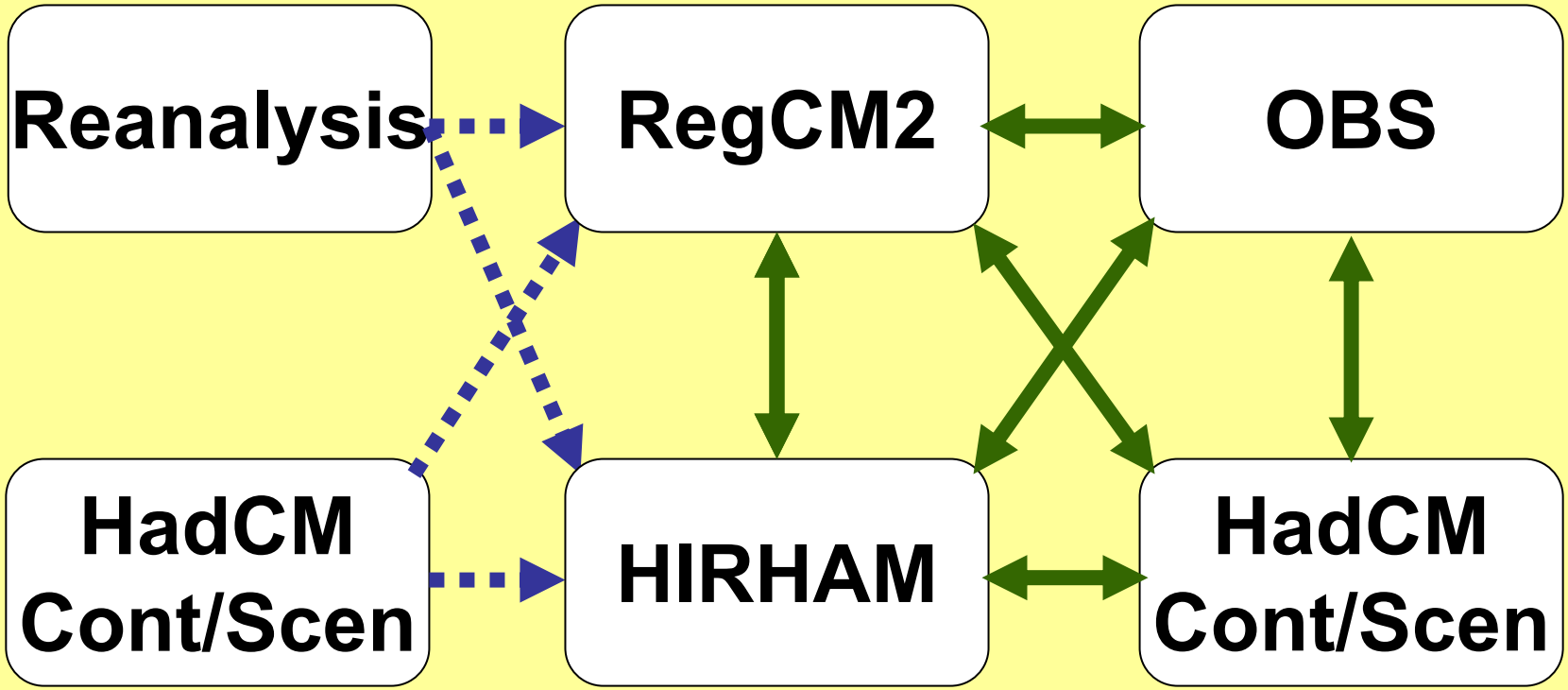
PIRCS: Approach and Lessons Learned

1. History - PIRCS 1a & 1b
2. PIRCS 1c
3. Spinoff: 10-yr “ensemble”
4. Transferability
5. Impacts
6. Summary

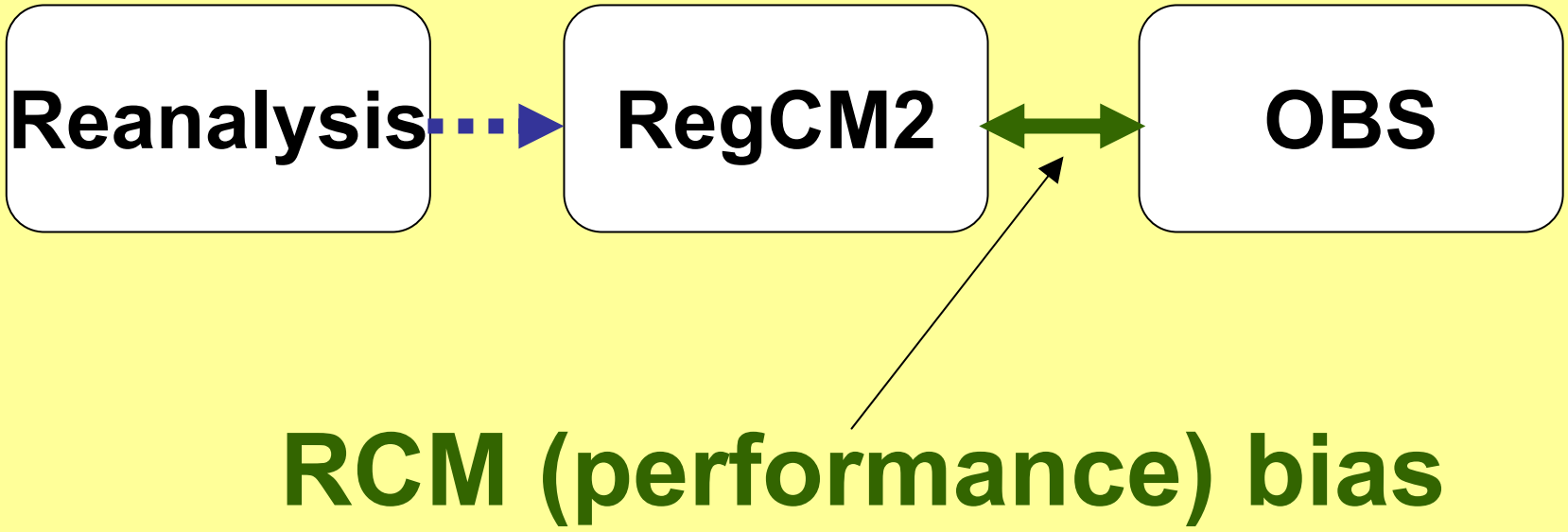
Simulations

Model	Observed	GCM-control	GCM-Scenario
RegCM2	NCEP Reanalysis (1979-1988)	Hadley Centre (~1990's)	Hadley Centre (2040-2050)
HIRHAM (DMI)	"	"	"

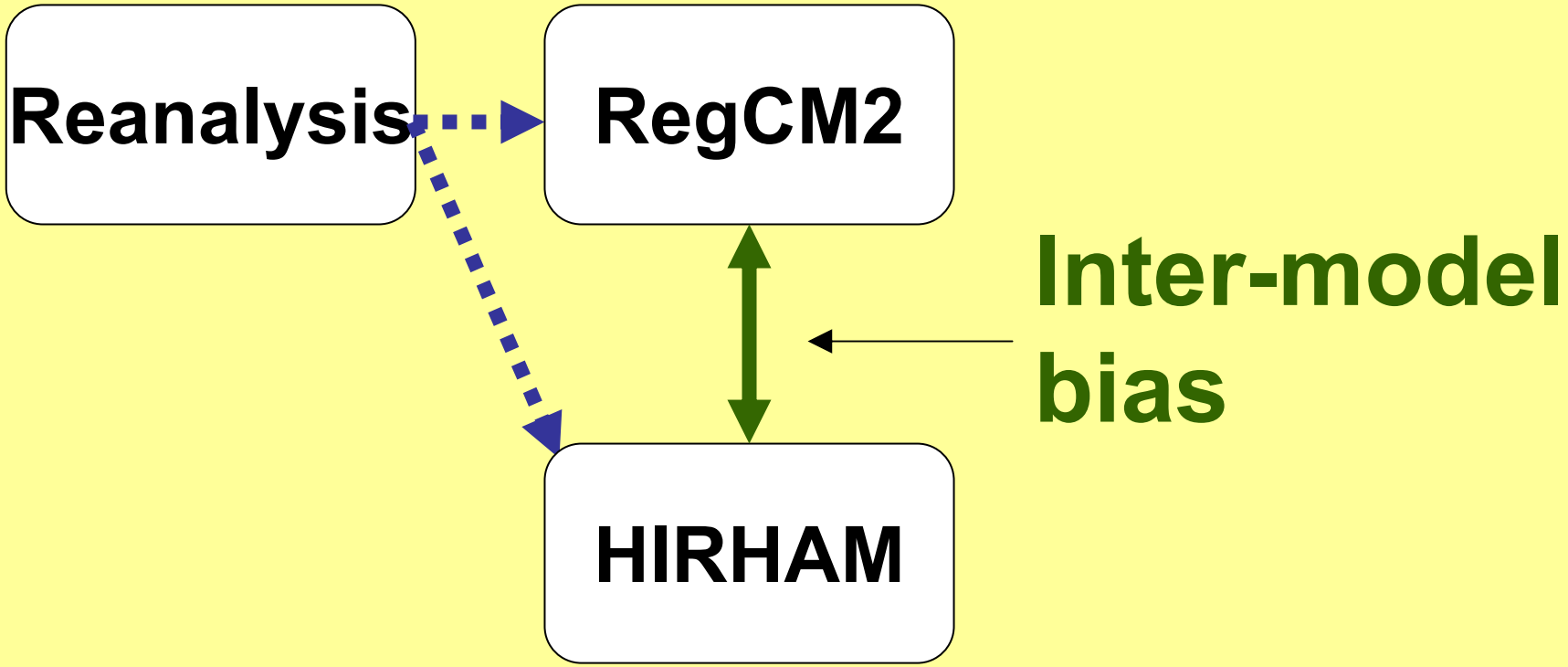
Possible Comparisons?



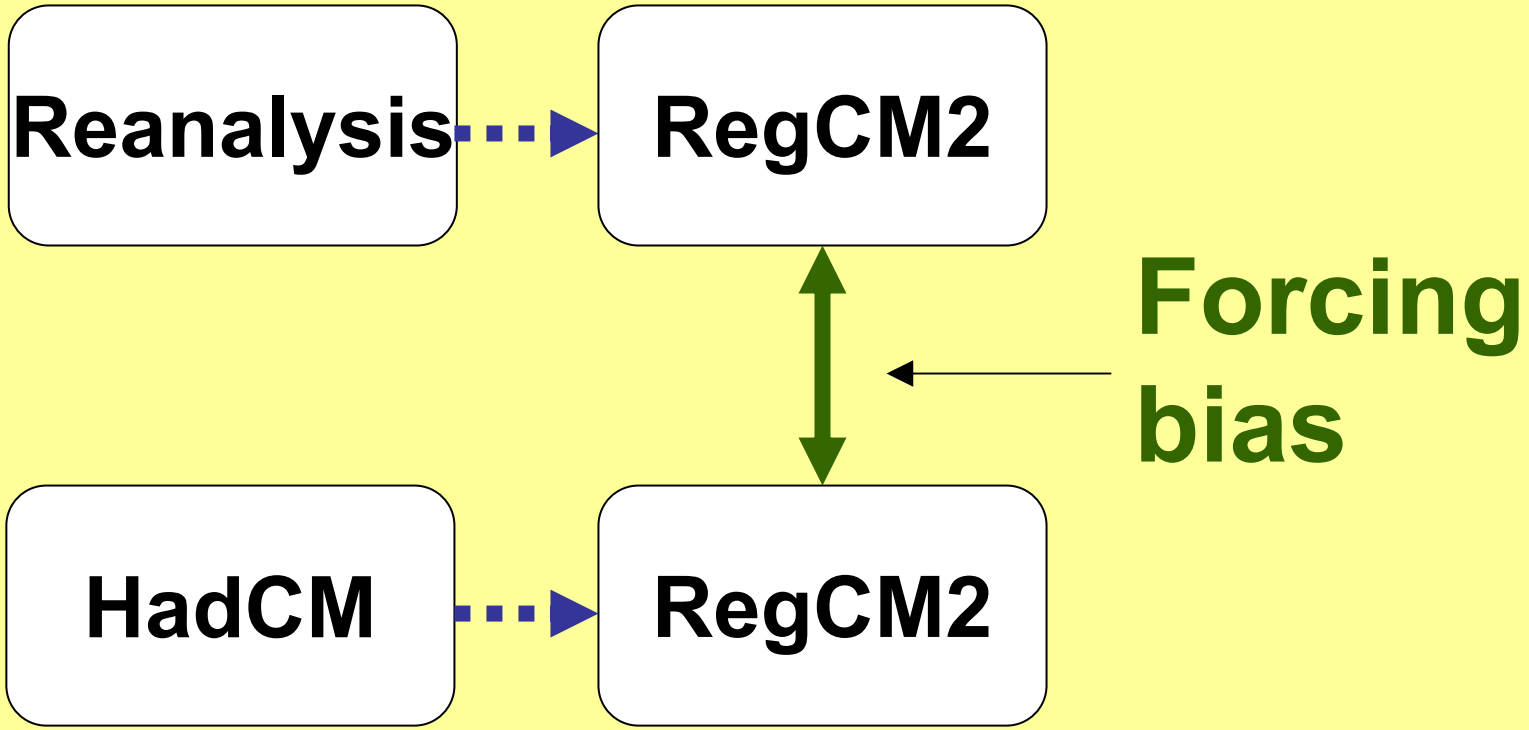
Definition of Biases



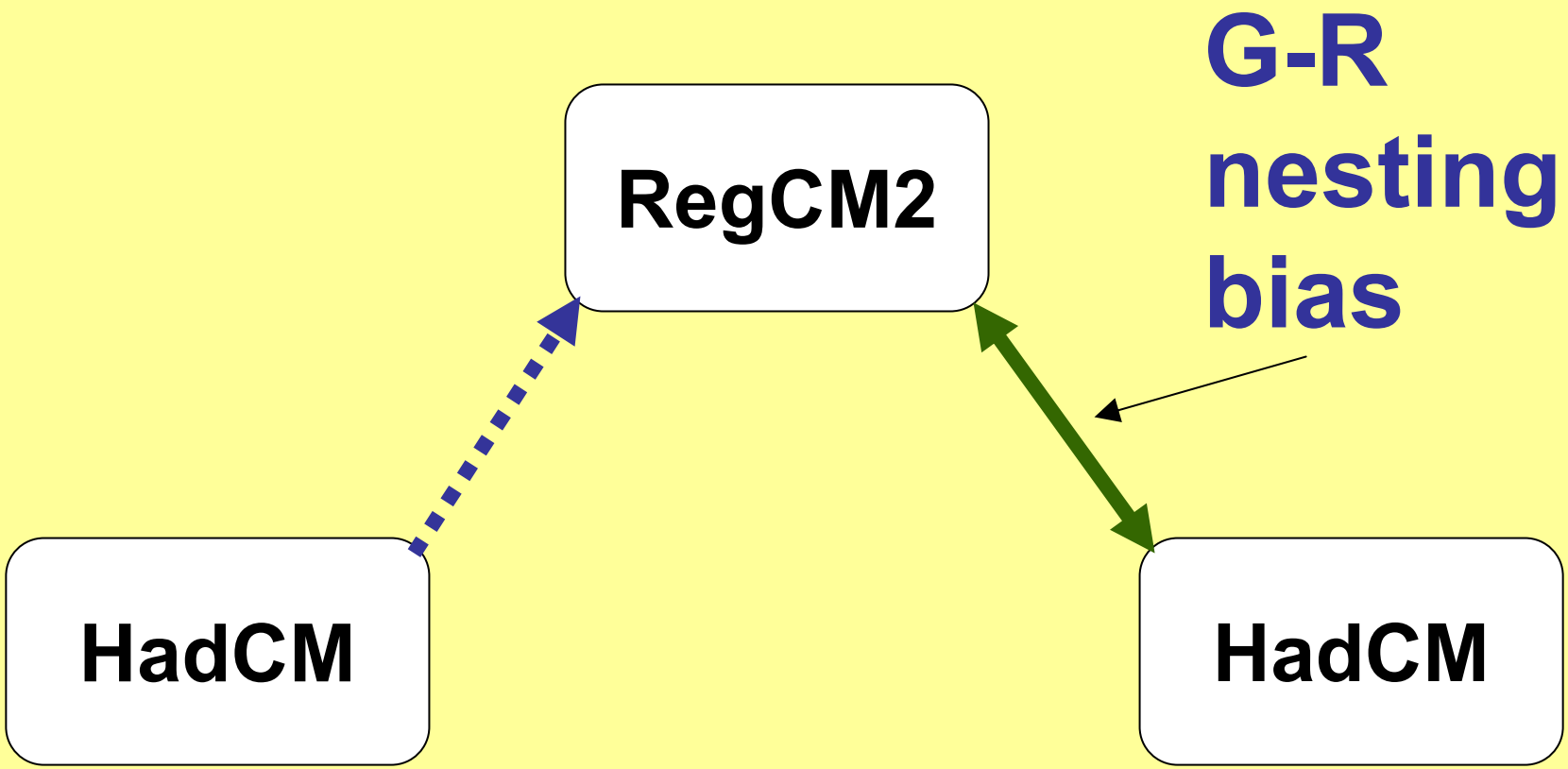
Definition of Biases



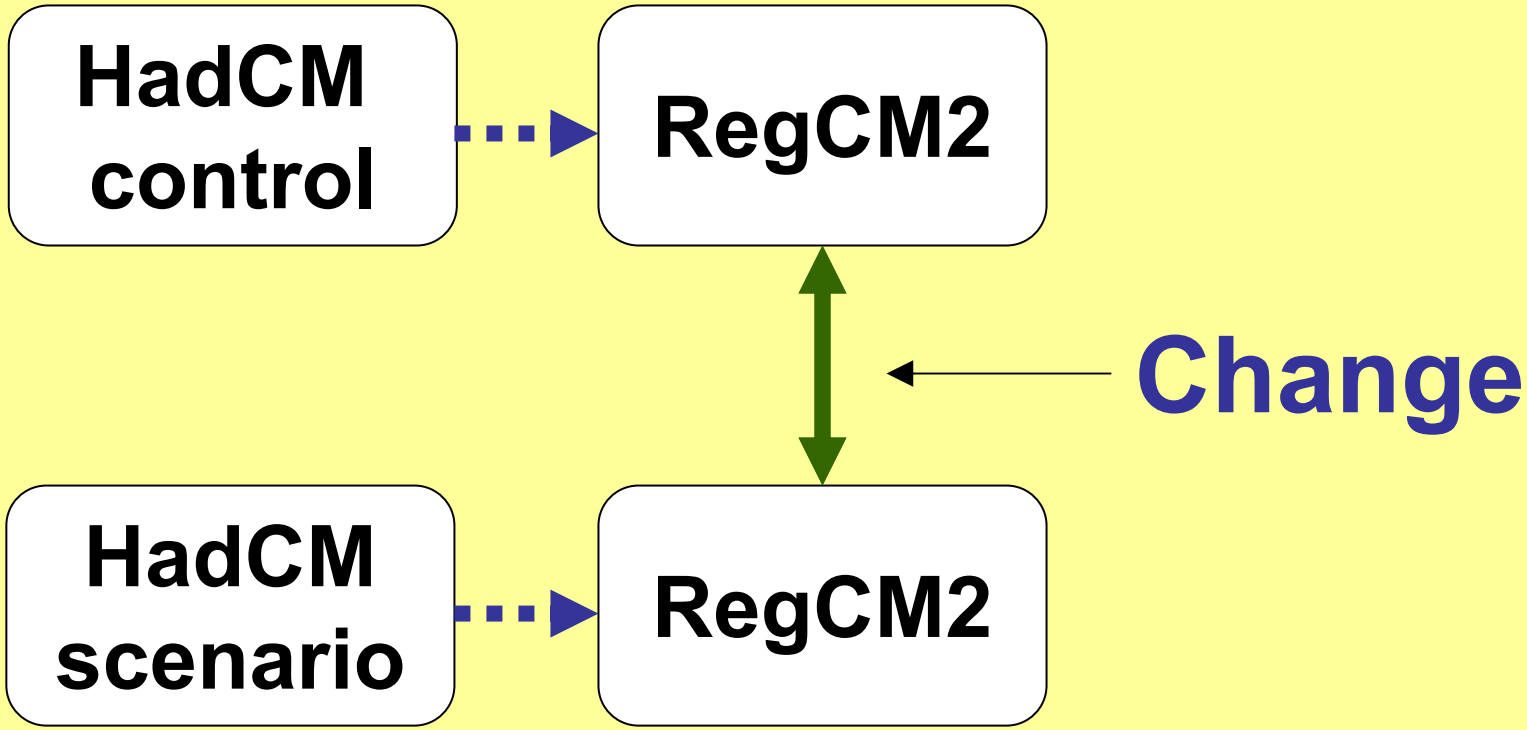
Definition of Biases



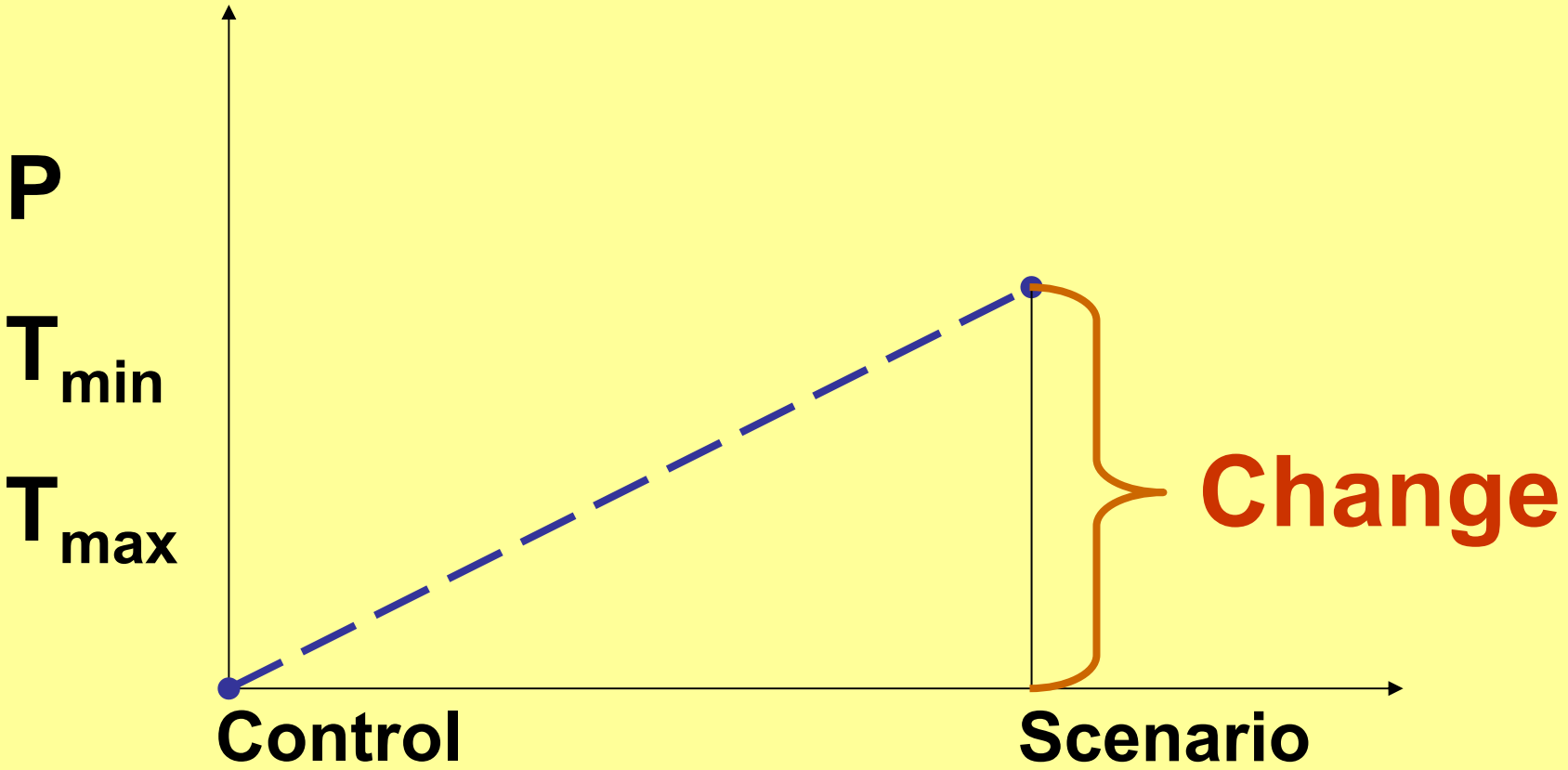
Definition of Biases



Climate Change

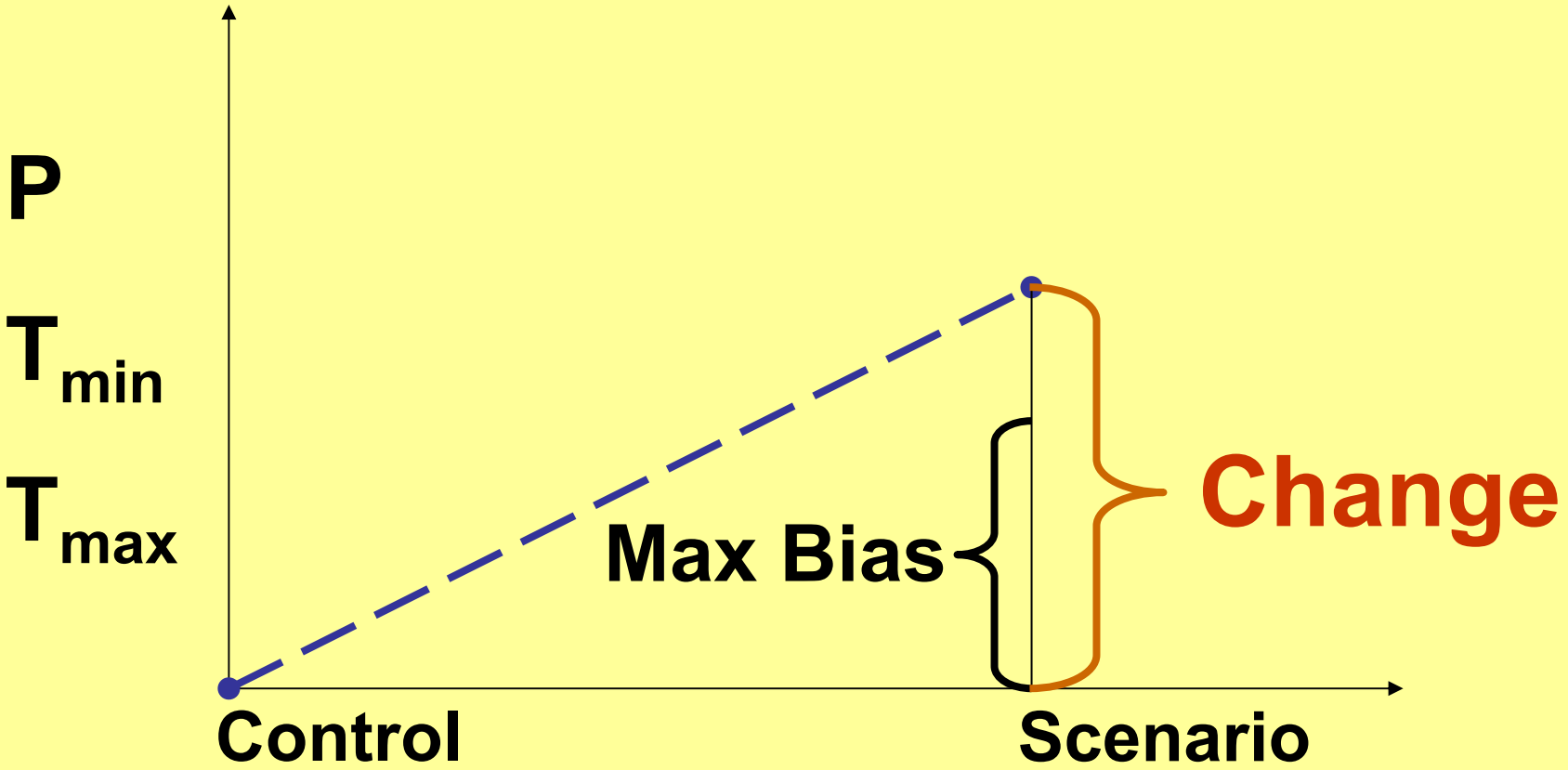


Climate Change



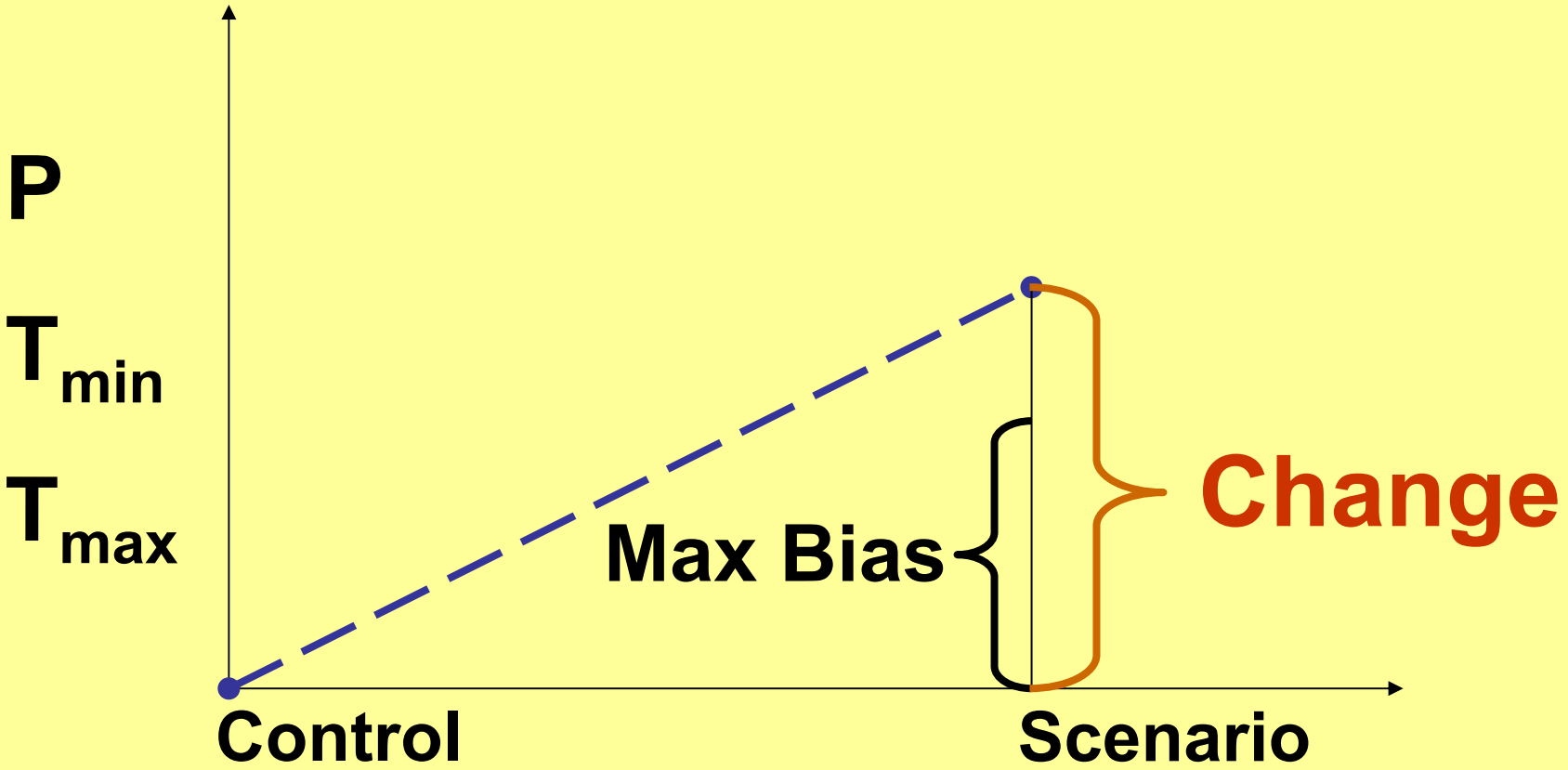
(Pan et al., JGR, 2001)

Climate Change



(Pan et al., JGR, 2001)

Climate Change

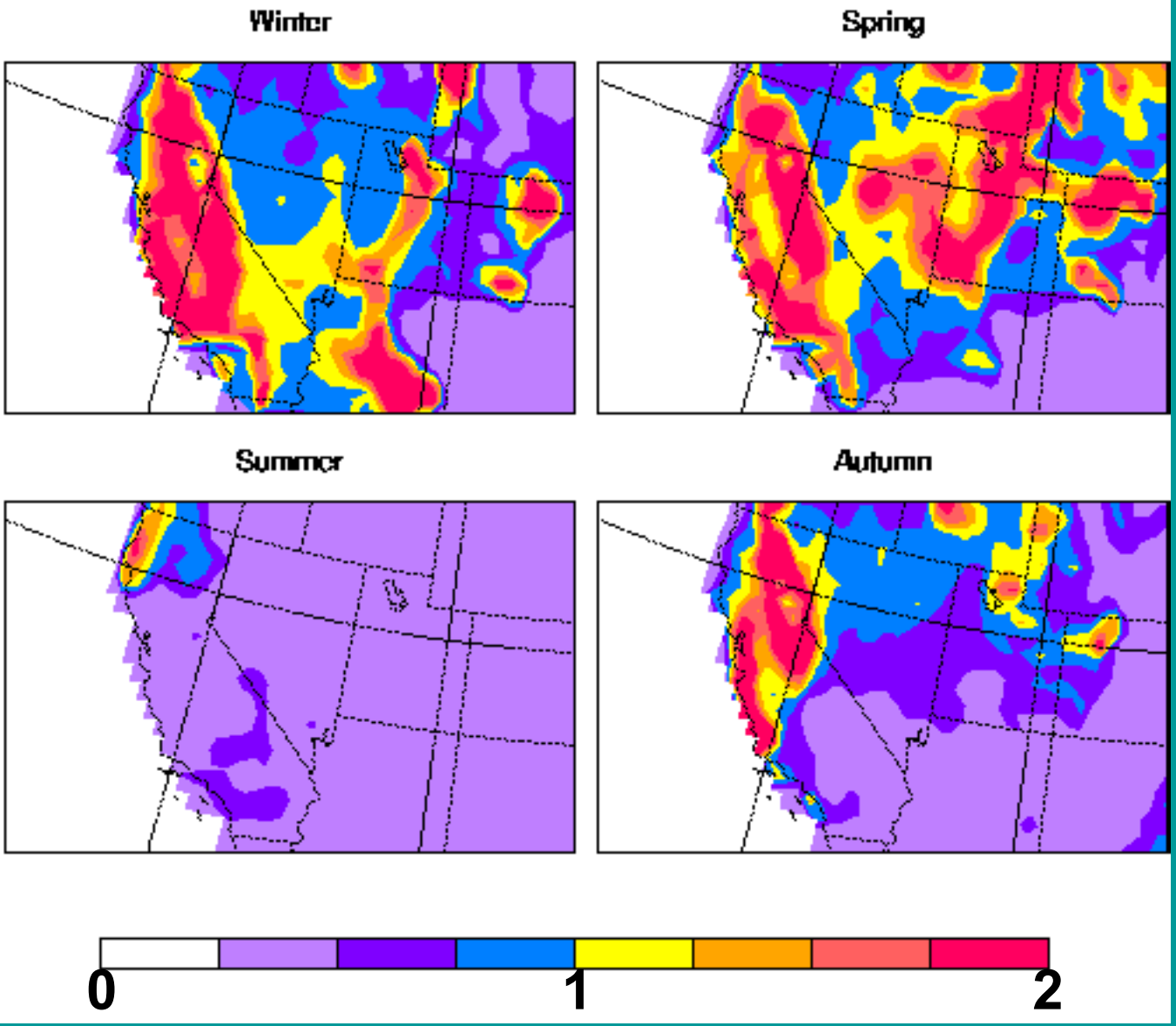


R_{chng} = Change / Max-Bias

(Pan et al., JGR, 2001)

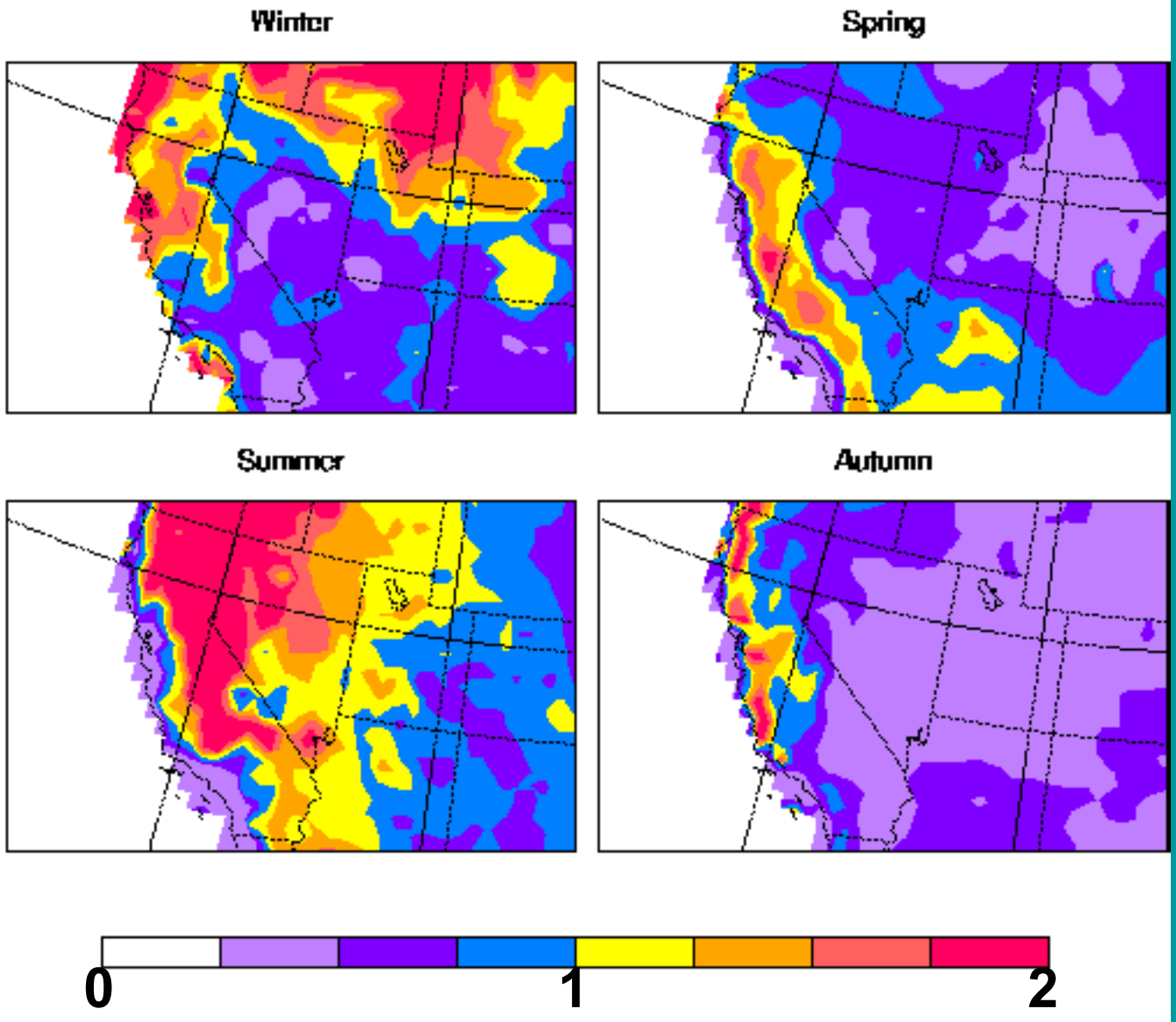
Climate Change Ratio - Precip (RegCM)

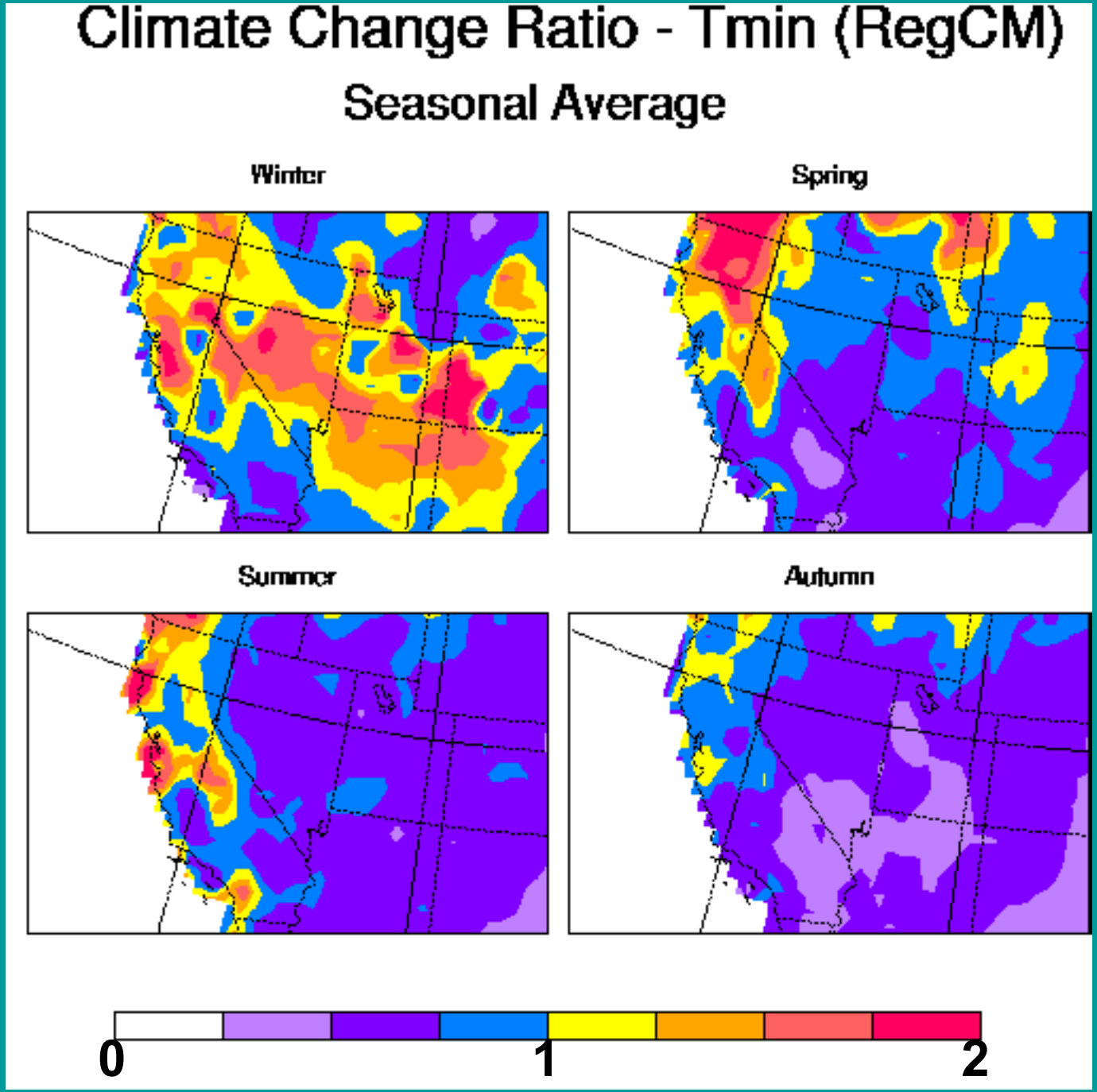
Seasonal Average



Climate Change Ratio - Tmax (RegCM)

Seasonal Average




Climate Change Ratio - Tmin (RegCM)
Seasonal Average
Winter
Spring
Summer
Autumn
0
1
2

PIRCS: Approach and Lessons Learned

1. History - PIRCS 1a & 1b
2. PIRCS 1c
3. Spinoff: 10-yr “ensemble”
4. Transferability
5. Impacts
6. Summary

Transferability Working Group
(proposed)
GEWEX Hydrometeorology Panel
World Climate Research Programme

Objective: ***Improved understanding and predictive capability through systematic intercomparisons of regional climate simulations on several continents with observations and analyses***

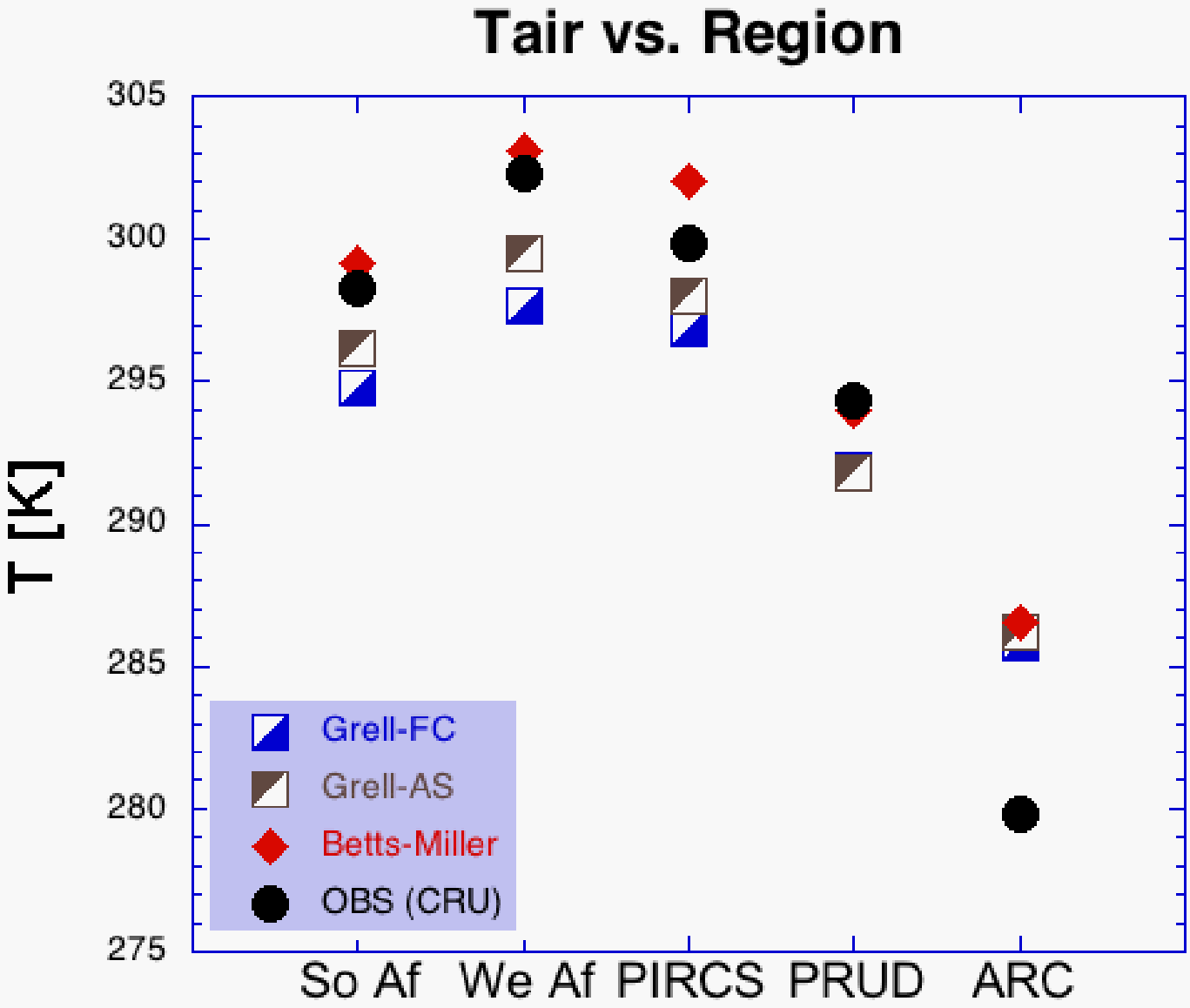
- Build on coordinated observations from GEWEX continental scale experiments
- Provide a framework for evaluating regional model simulations of climate processes of different climatic regions.
- Evaluate transferability of regional climate models, for example a model developed to study one region as applied to other, "non-native", regions
- Examine individual and ensemble performance between domains and on individual domains

Proposal coordinated by
E. S. Takle, W. J. Gutowski, Jr., and R. W. Arritt
Iowa State University

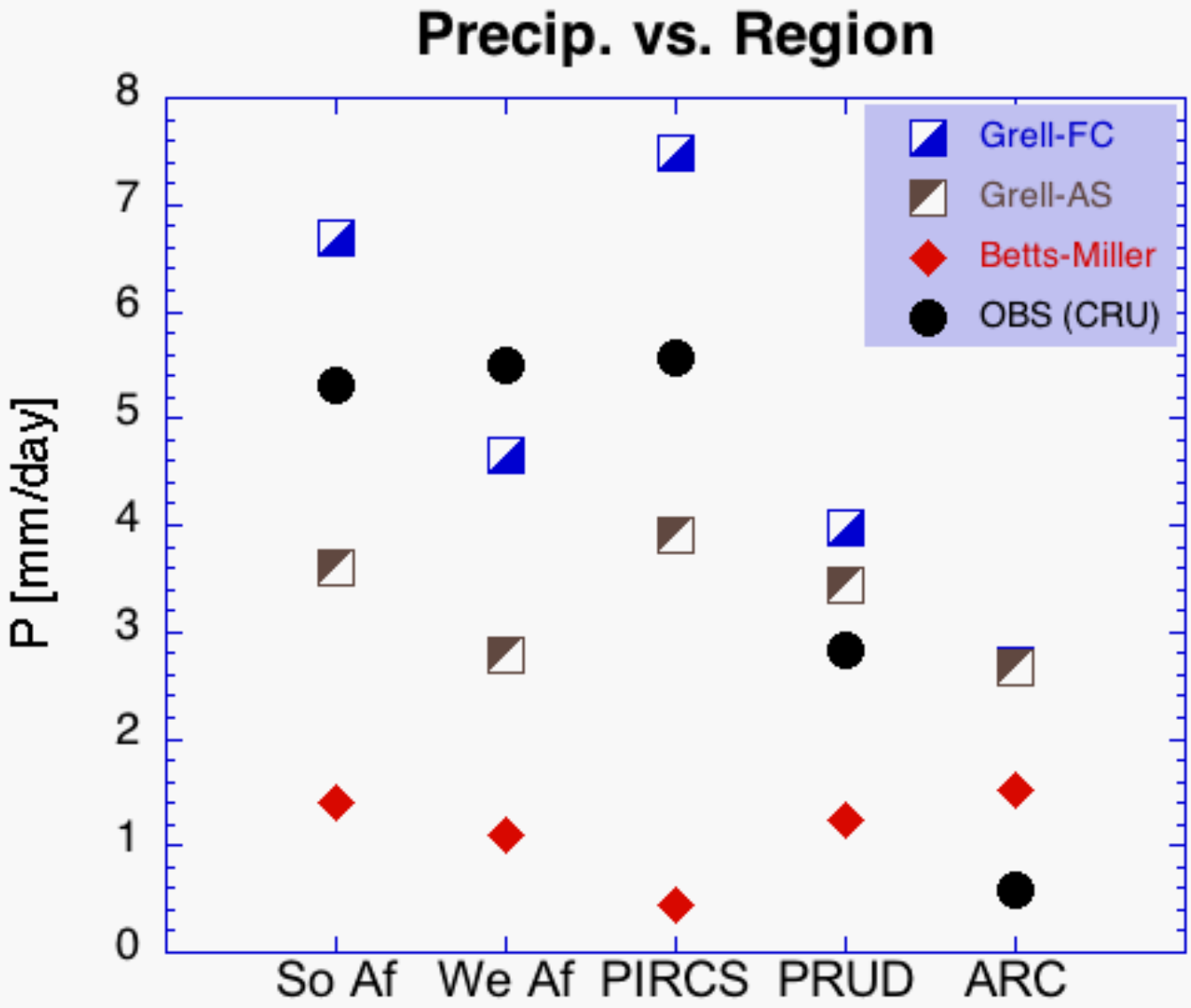
Relevance to California?

- “When climate changes, will your model be ready?”
- How do models perform elsewhere?

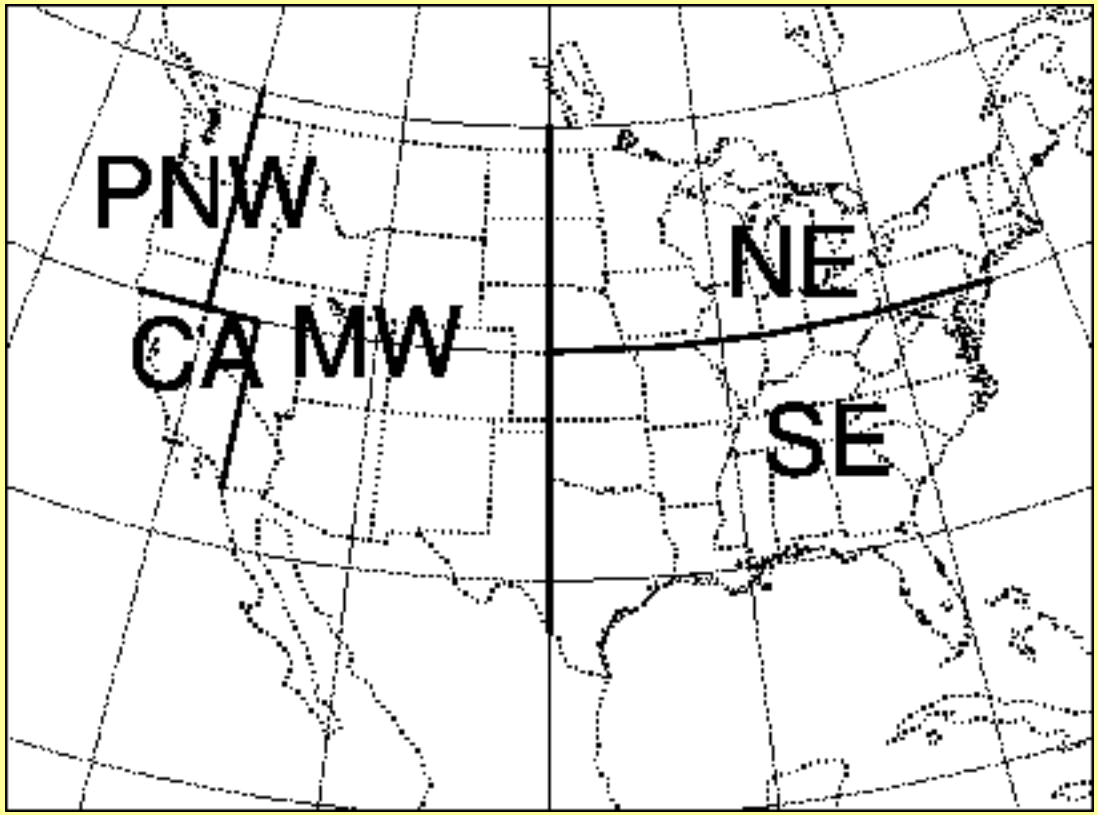
RegCM3 Simulations - Various Regions

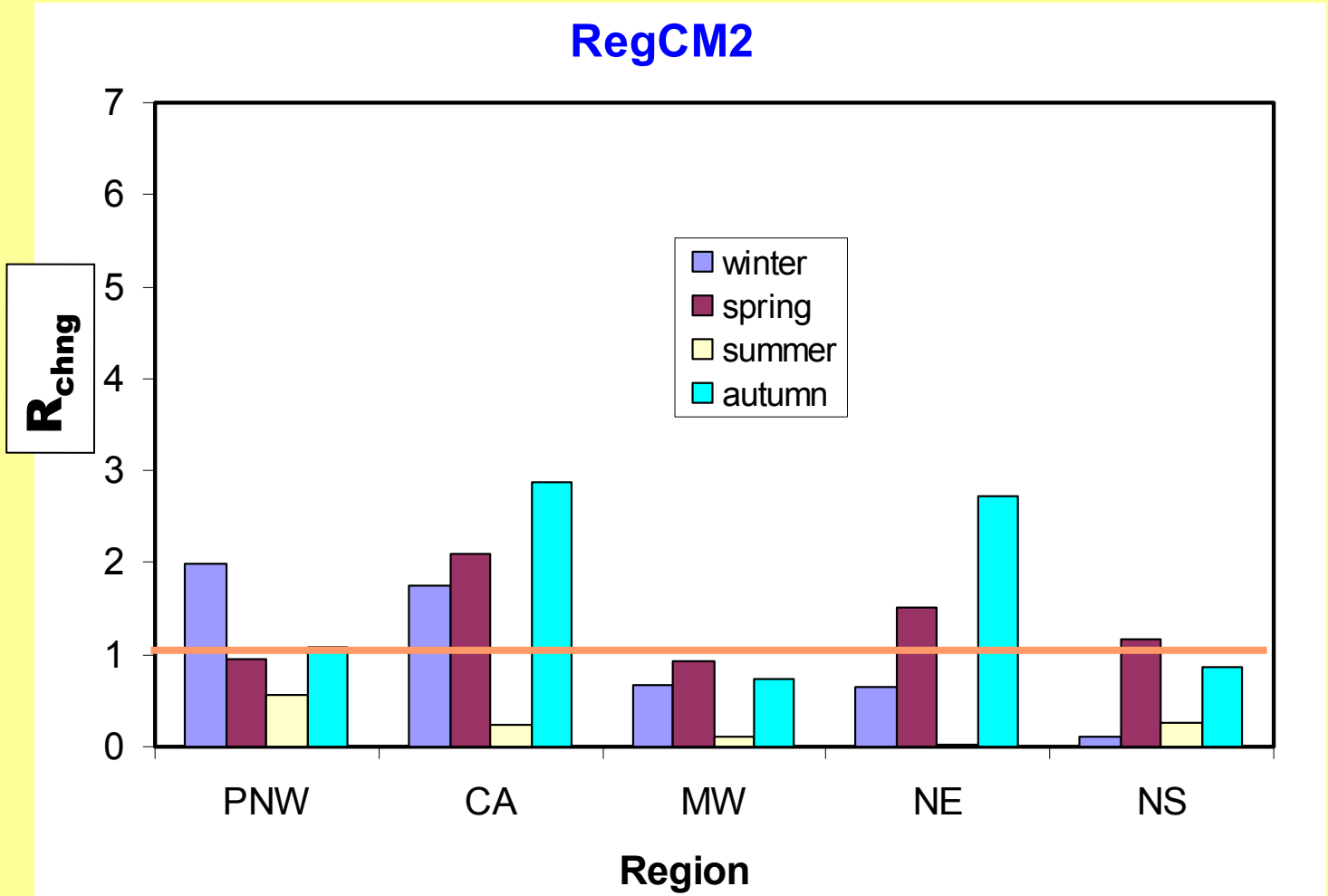


RegCM3 Simulations - Various Regions

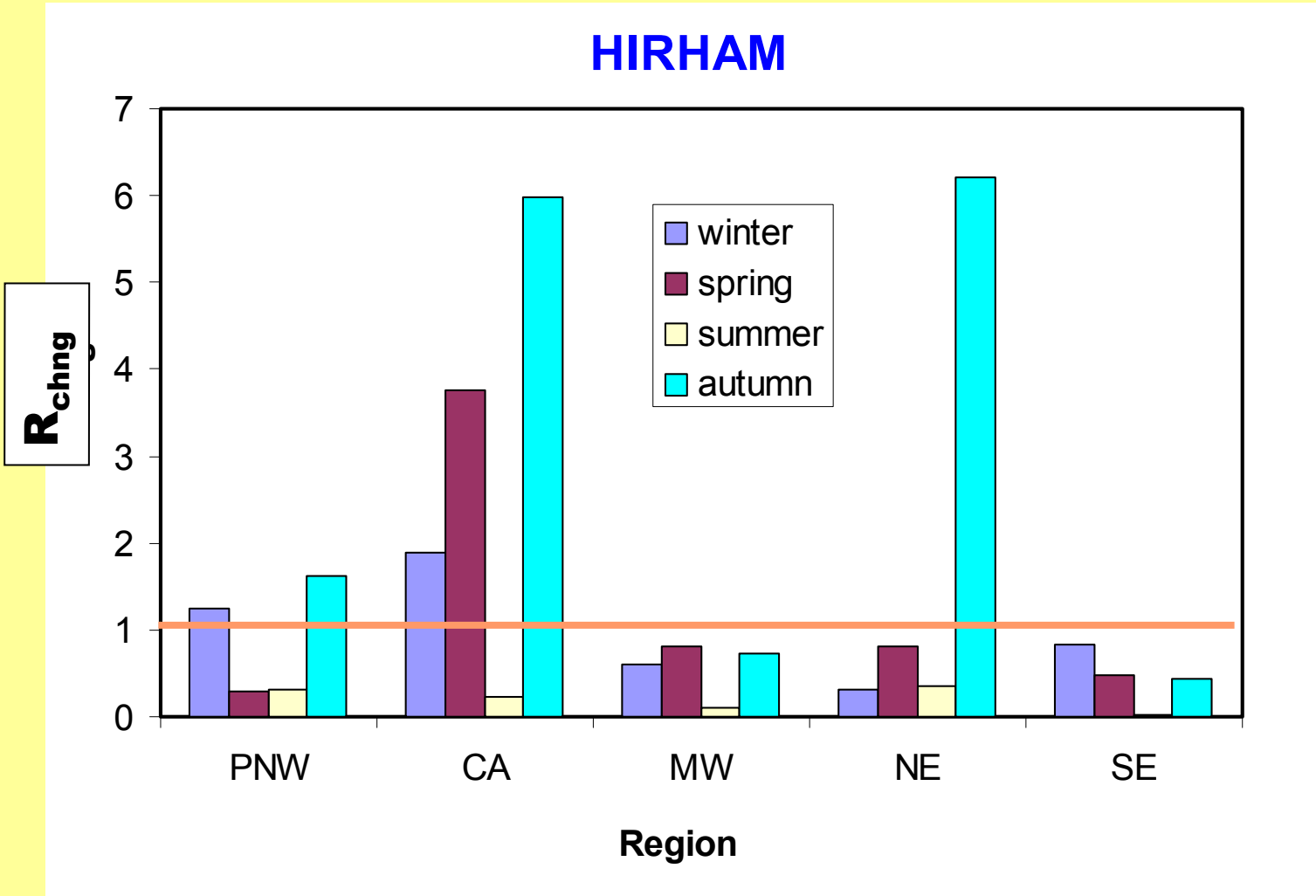


Analysis Regions





$$R_{chng} = \frac{\left|\Delta P_{chng}\right|}{Max\left(\Delta P_{RCM}, \Delta P_{forc}, \Delta P_{itmd}\right)}$$


HIRHAM
R_{chng}
7
6
5
4
3
2
1
0
winter
spring
summer
autumn
PNW
CA
MW
NE
SE
Region

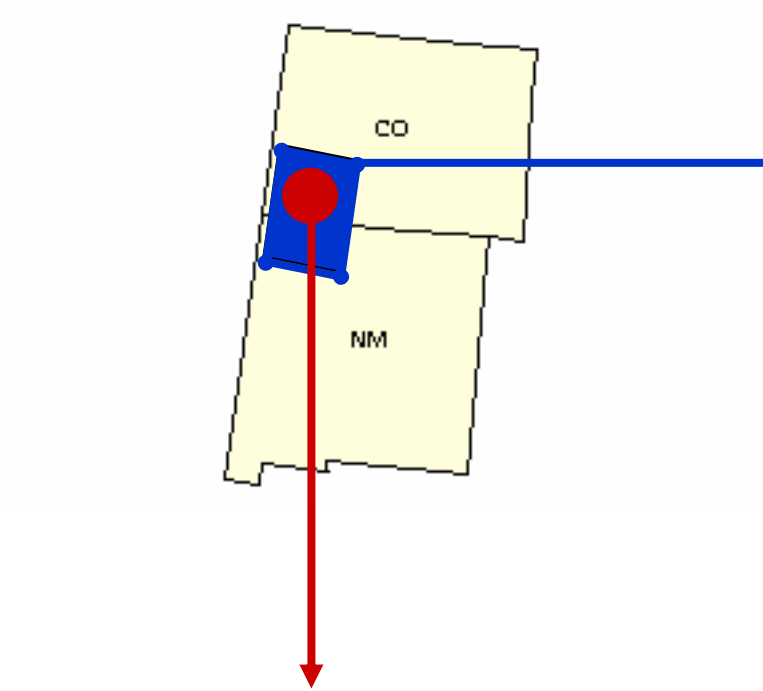
Relevance to California?

- "When climate changes, will your model be ready?"
- How do models perform elsewhere?
- Results suggest using large enough area to encompass other climatic regions.

PIRCS: Approach and Lessons Learned

1. History - PIRCS 1a & 1b
2. PIRCS 1c
3. Spinoff: 10-yr “ensemble”
4. Transferability
5. Impacts
6. Summary

BASINS

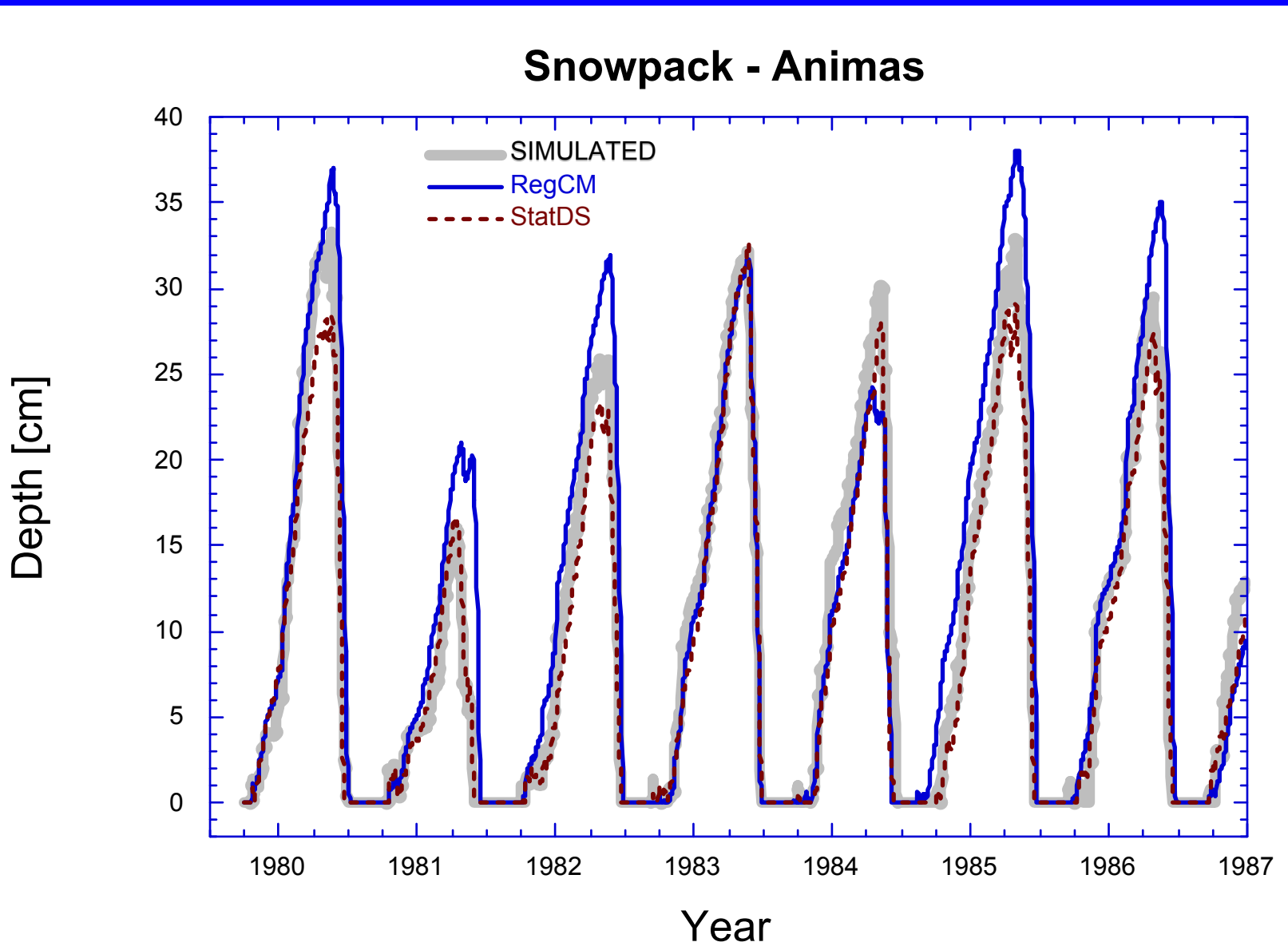


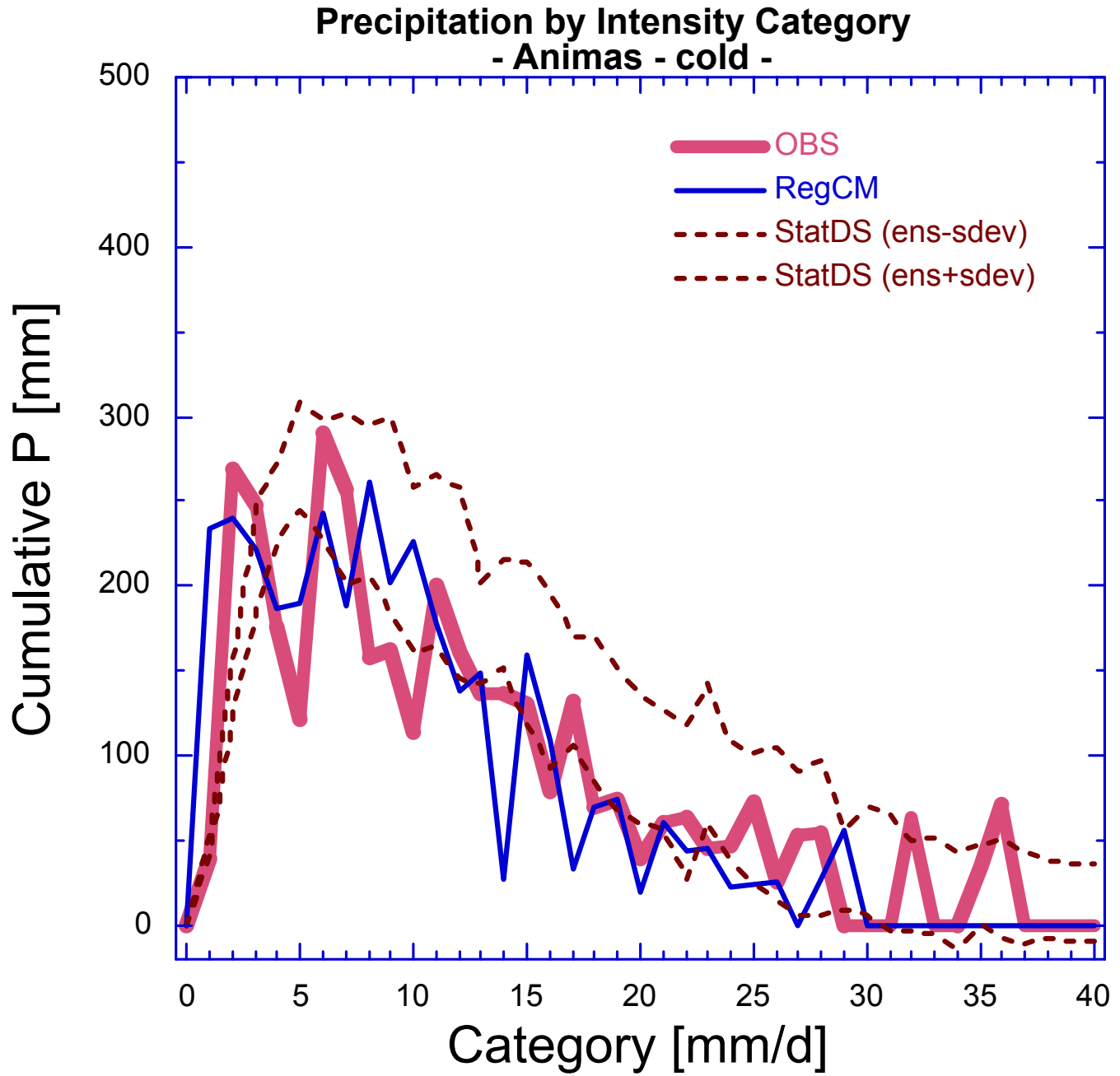
San Juan

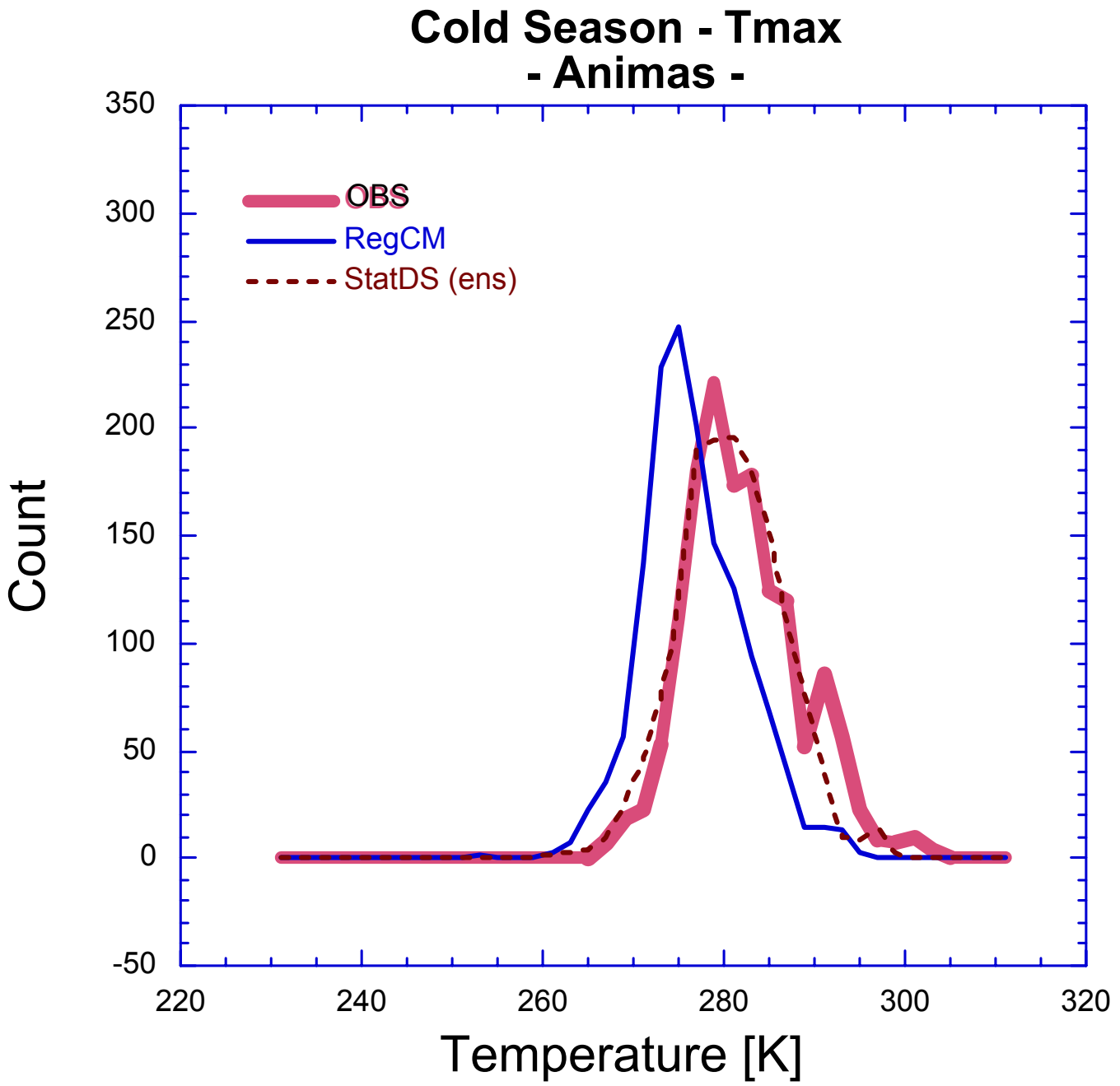
Obs. Stations	Model Points
37	16

Animas

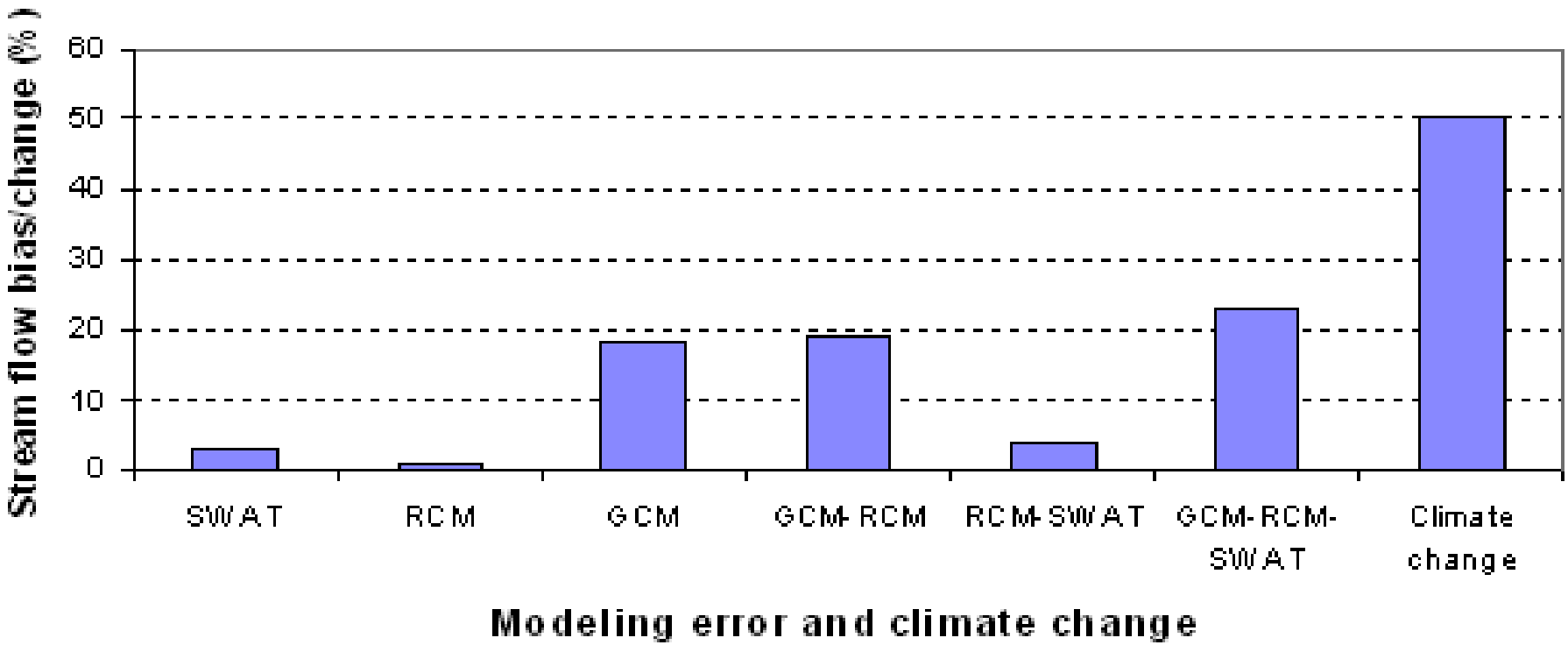
Obs. Stations	Model Points
3	3


Snowpack - Animas
SIMULATED
RegCM
StatDS
Depth [cm]
0
5
10
15
20
25
30
35
40
1980
1981
1982
1983
1984
1985
1986
1987
Year

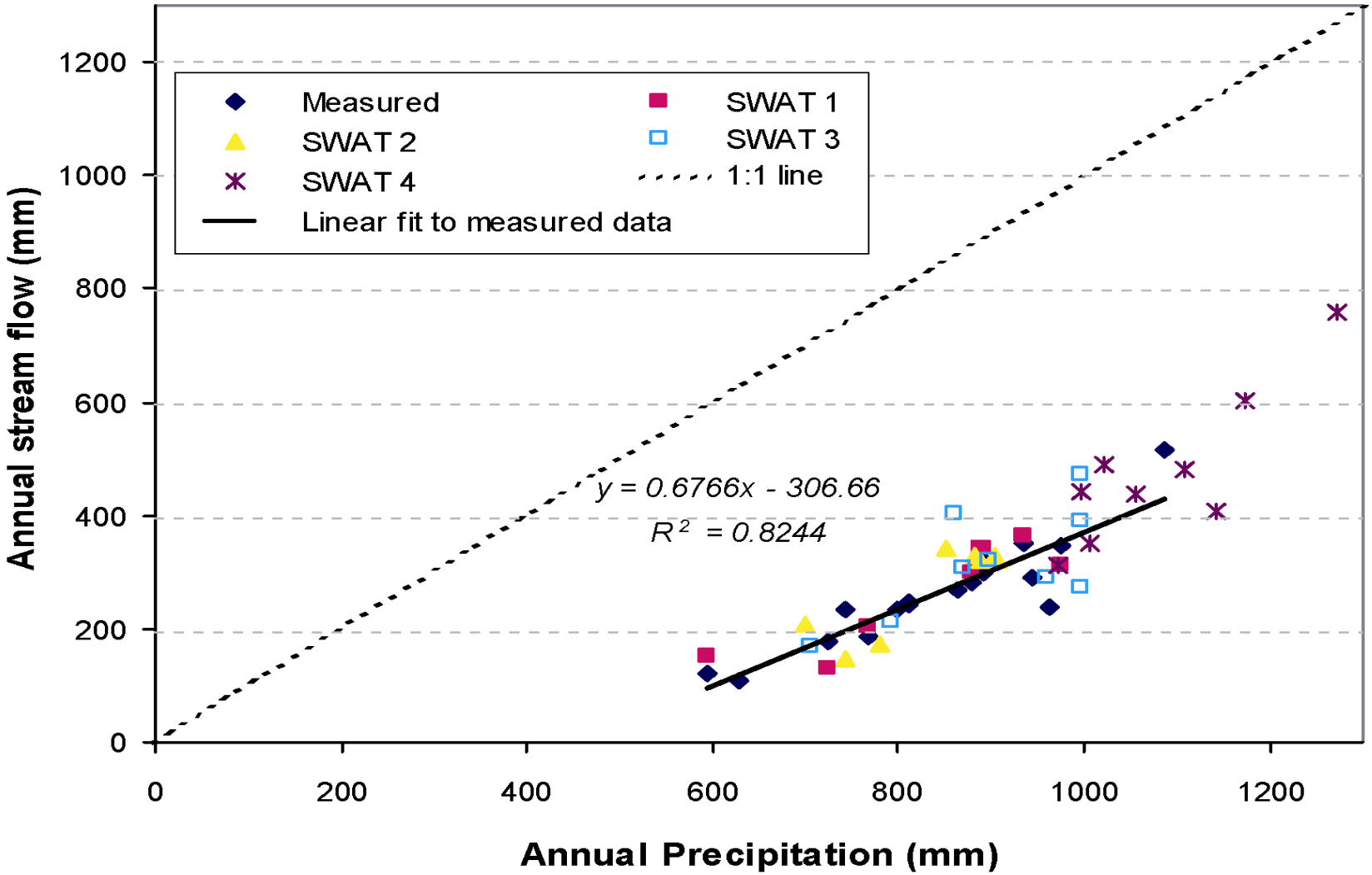

Precipitation by Intensity Category
- Animas - cold -
OBS
RegCM
StatDS (ens-sdev)
StatDS (ens+sdev)
Cumulative P [mm]
500
400
300
200
100
0
0
5
10
15
20
25
30
35
40
Category [mm/d]


Cold Season - Tmax
- Animas -
OBS
RegCM
StatDS (ens)
Count
Temperature [K]
350
300
250
200
150
100
50
0
-50
220
240
260
280
300
320

Comparison of Simulated Stream Flow under Climate Change with Various Model Biases



Relation of Runoff to Precipitation for Various Climates



Yield Summary
(all in kg/ha)

	Mean	St. Dev.
Observed Yields	8381	1214
Simulated by CERES with		
Observed weather	8259	4494
RegCM2/NCEP	5487	3796
HIRHAM/NCEP	3446	2716
RegCM2/HadCM2 current	5002	1777
HIRHAM/HadCM2 current	6264	3110

Yield Summary

- Deficiencies in RCMs and GCMs for driving crop models likely is due to poor timing and amounts of precipitation
- Crop models expose and amplify vegetation-sensitive climate features of a GCM or RCM

PIRCS: Approach and Lessons Learned

1. History - PIRCS 1a & 1b
2. PIRCS 1c
3. Spinoff: 10-yr “ensemble”
4. Transferability
5. Impacts
6. Summary

PIRCS: Lessons Learned

1. Ensembles are important
2. Models have common precipitation biases (daily and interannual)
3. Must understand model behavior in a variety of climates
4. Two-way interaction with impacts groups is vital
5. Require common data formatting

Acknowledgements

- **Primary Funding:**
  Electric Power Research Institute (EPRI)
  NOAA
- **Guidance/Support:**
  Andrew Staniforth, Eugenia Kalnay,
  Filippo Giorgi, Roger Pielke, AMIP group
- **Special Thanks:**
  Participating Modelers

http://rcmlab.agron.iastate.edu

IOWA STATE UNIVERSITY

PIRCS Project to Intercompare Regional Climate Simulations

Without sufficient resolution, it just doesn't look right.